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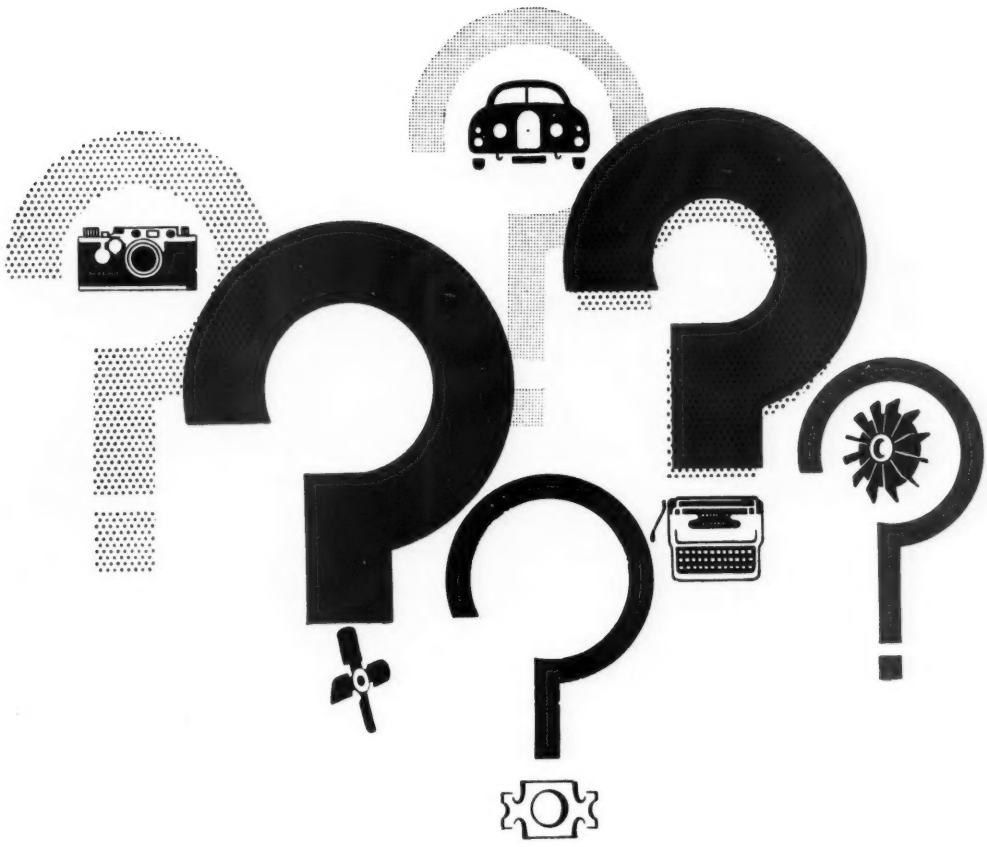

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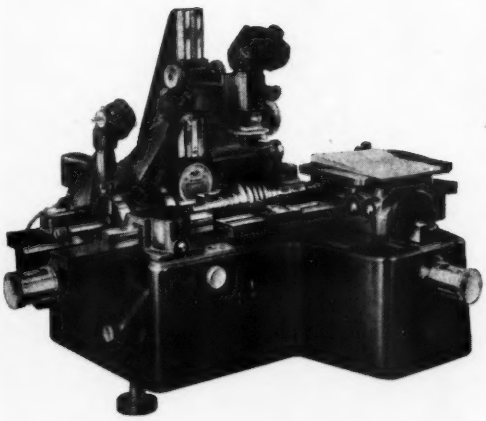

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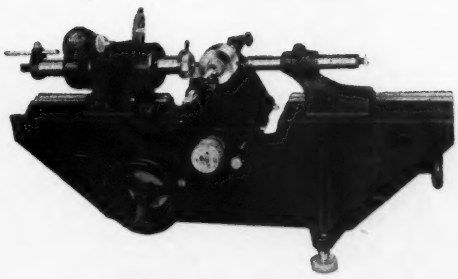

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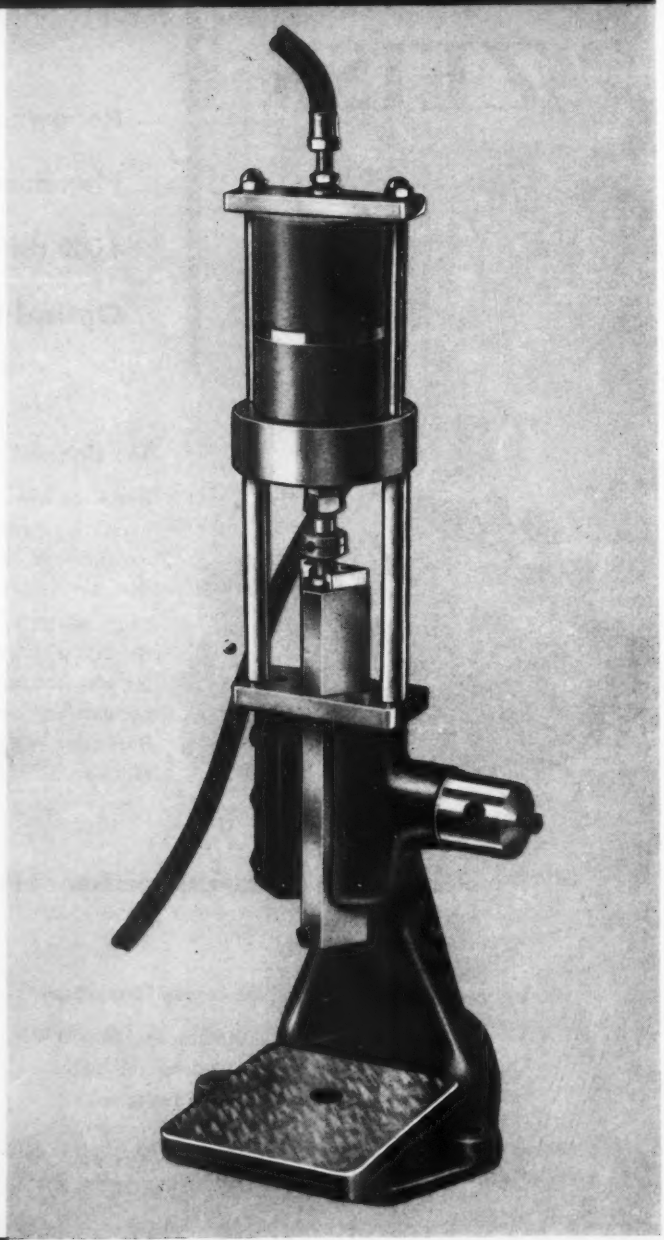

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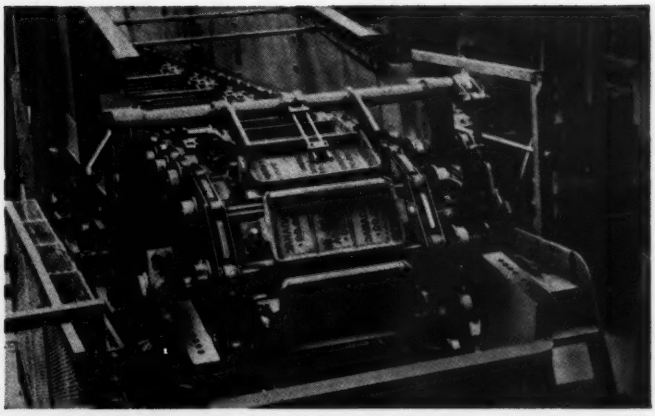

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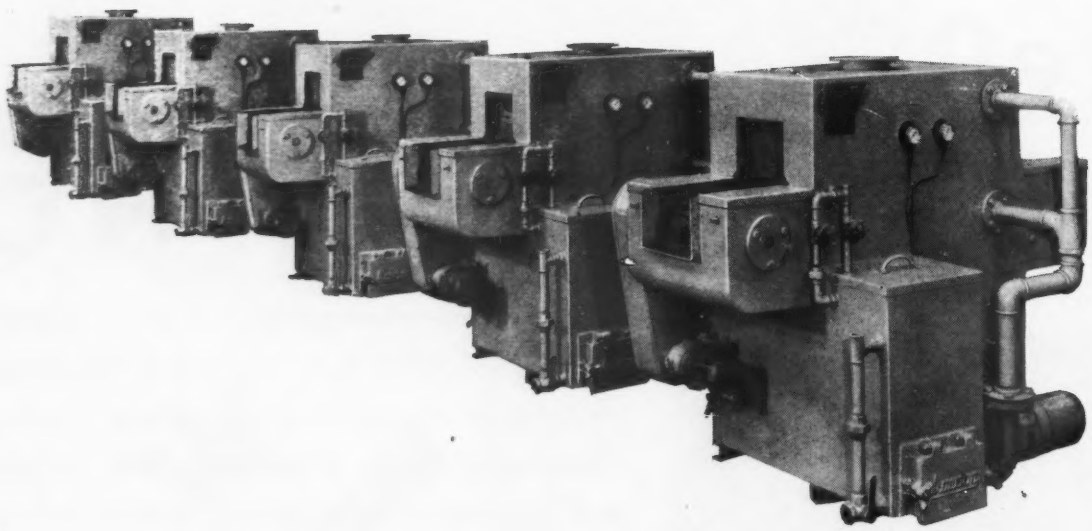

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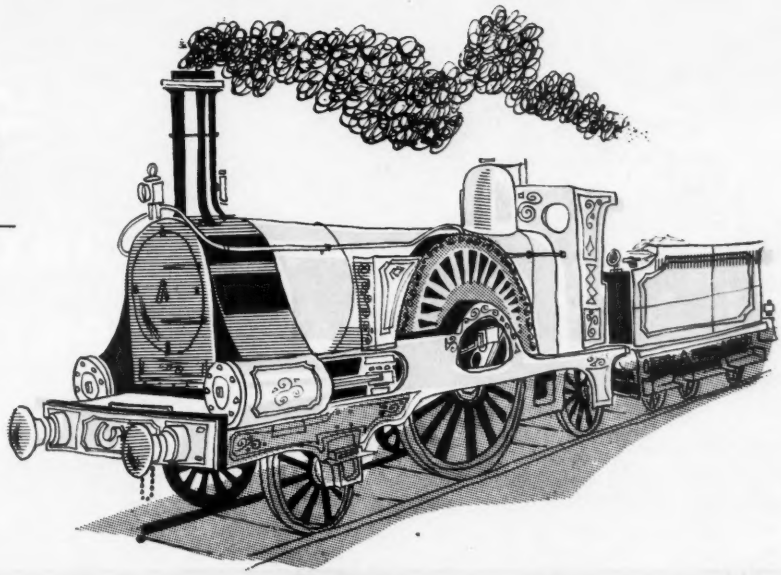

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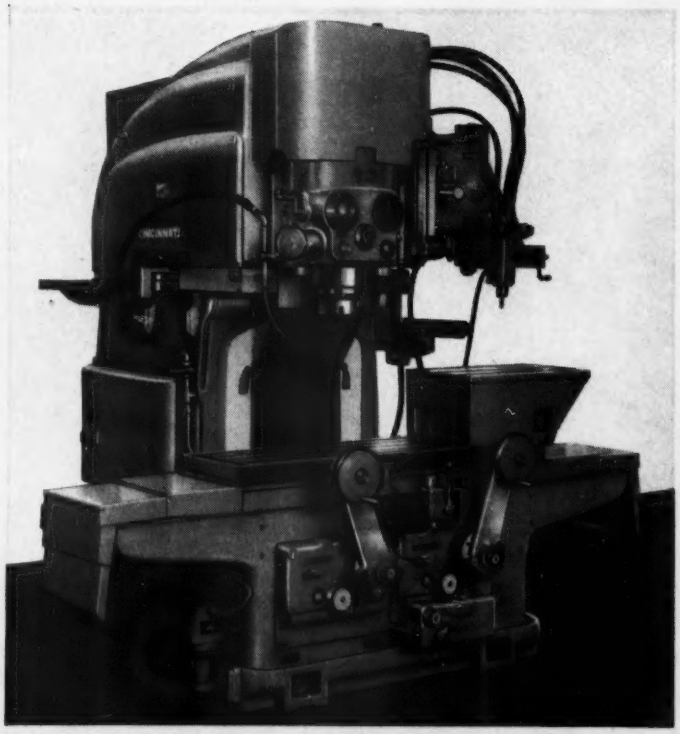

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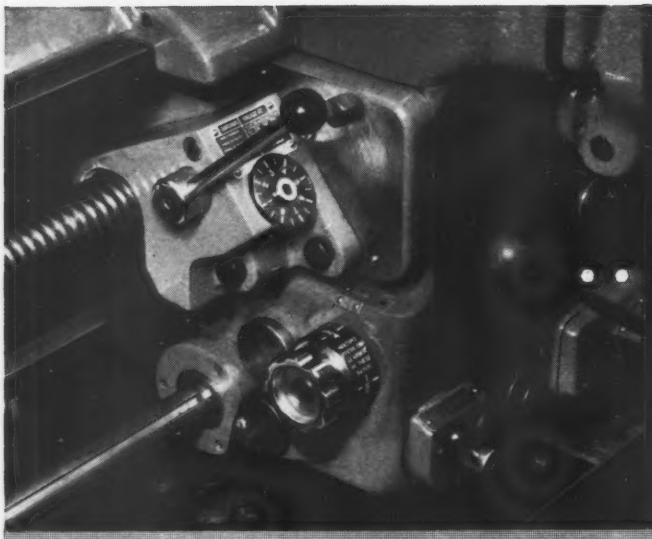

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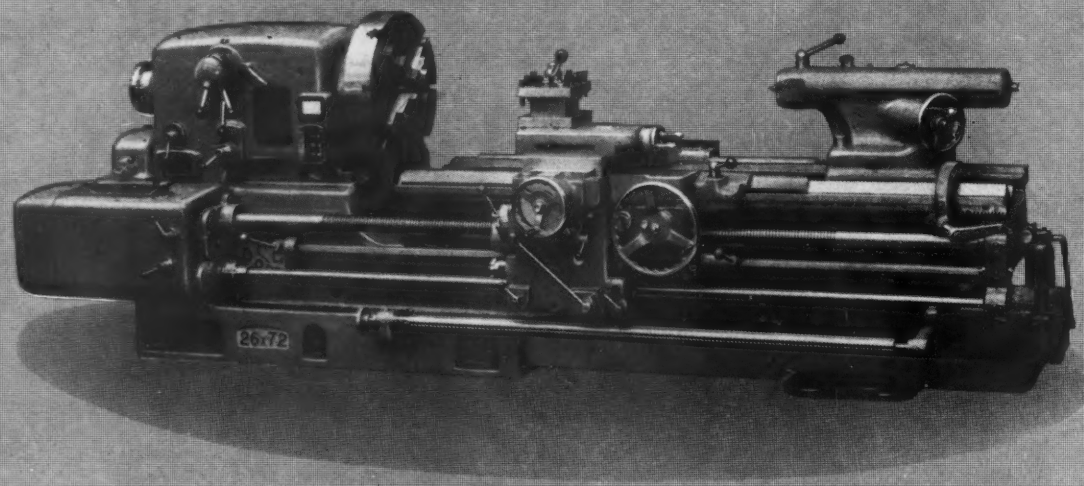

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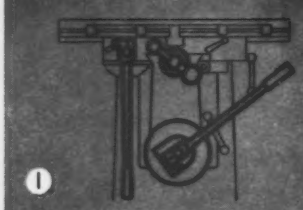

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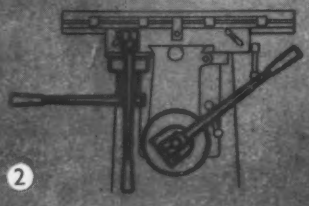

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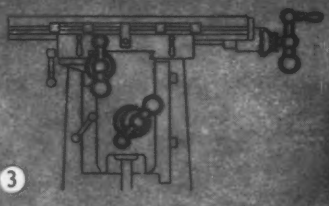
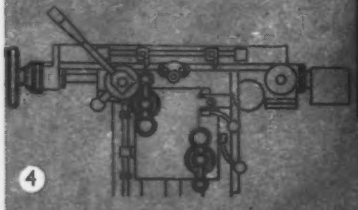


3 Hand Feed—Screw, screw, screw.



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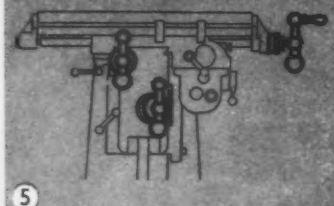
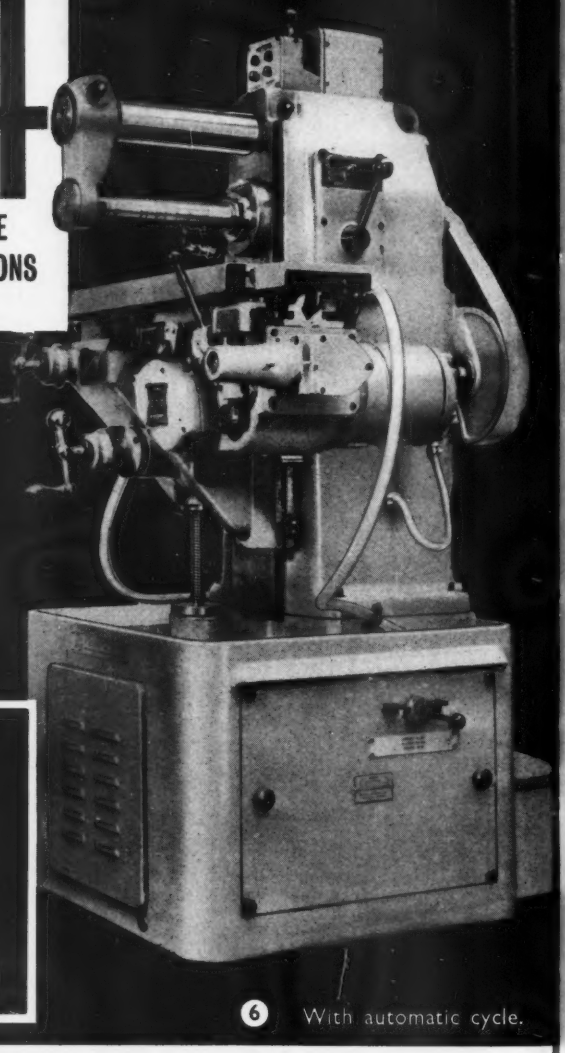


5 Normal automatic feed.



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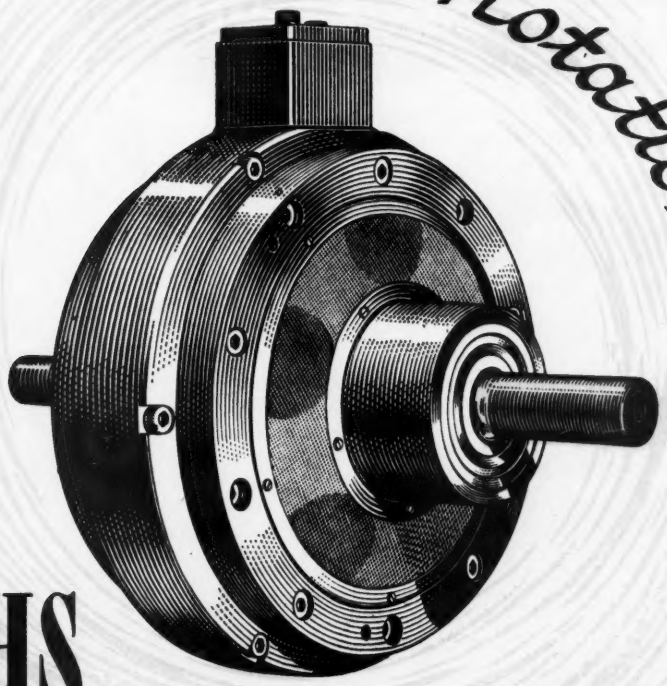

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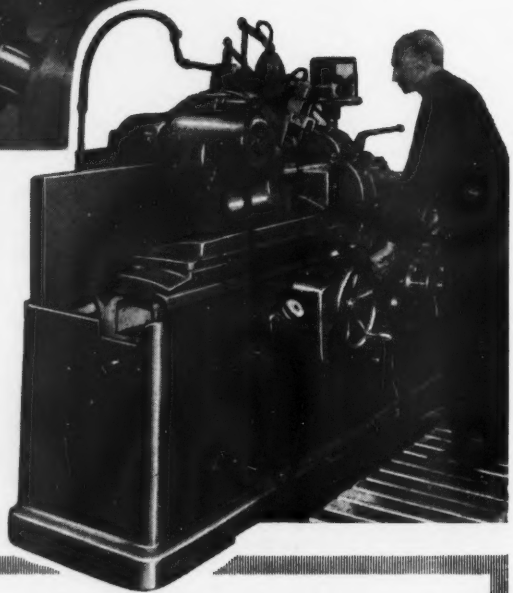

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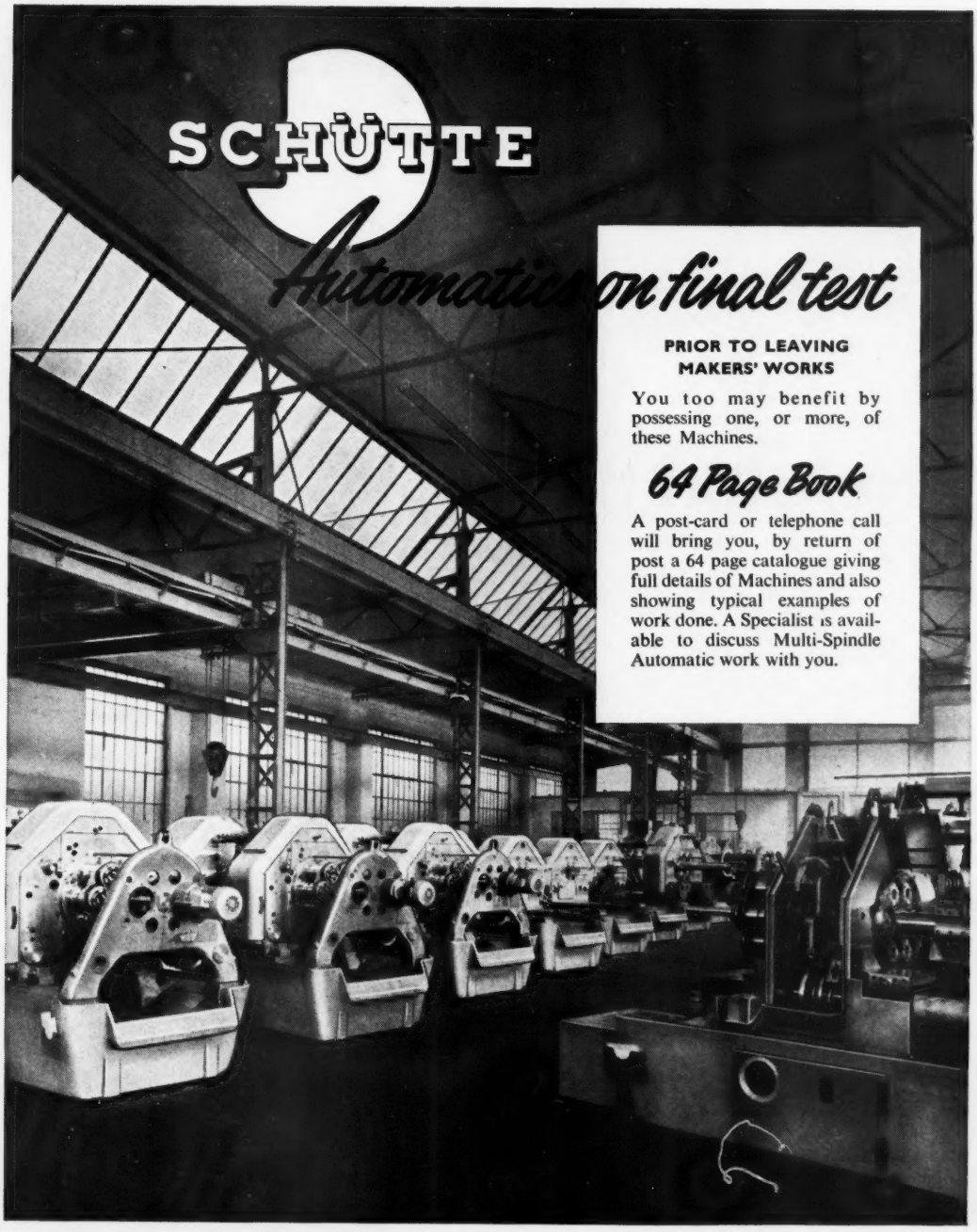
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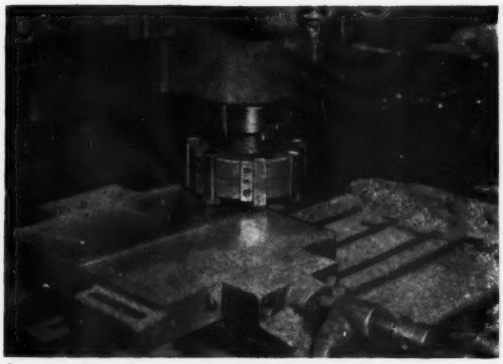

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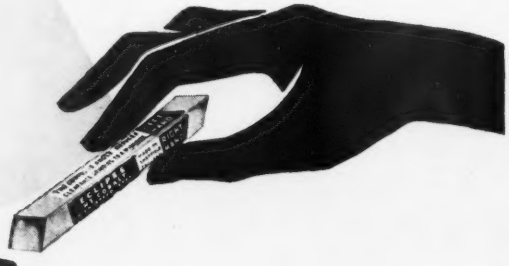

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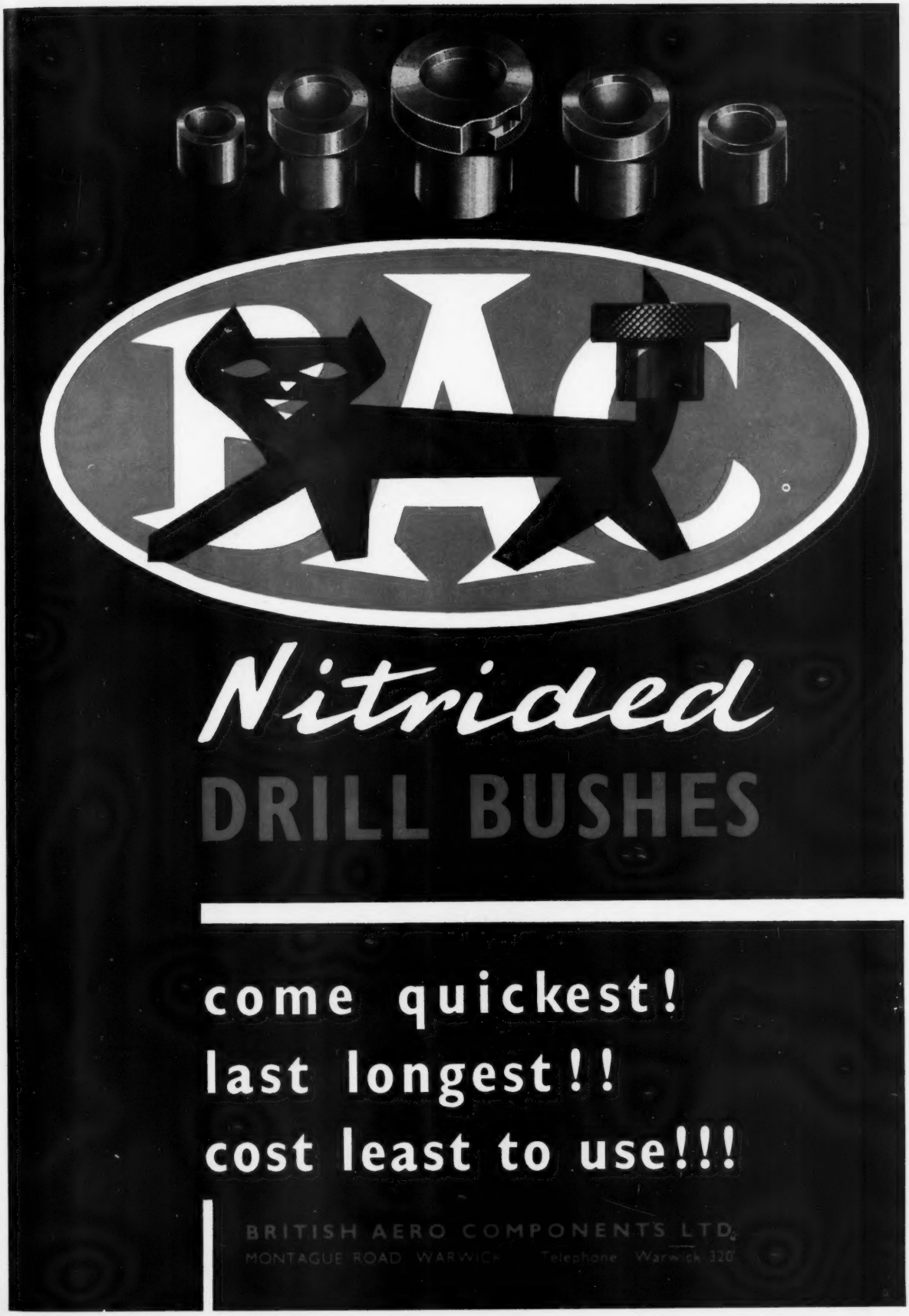
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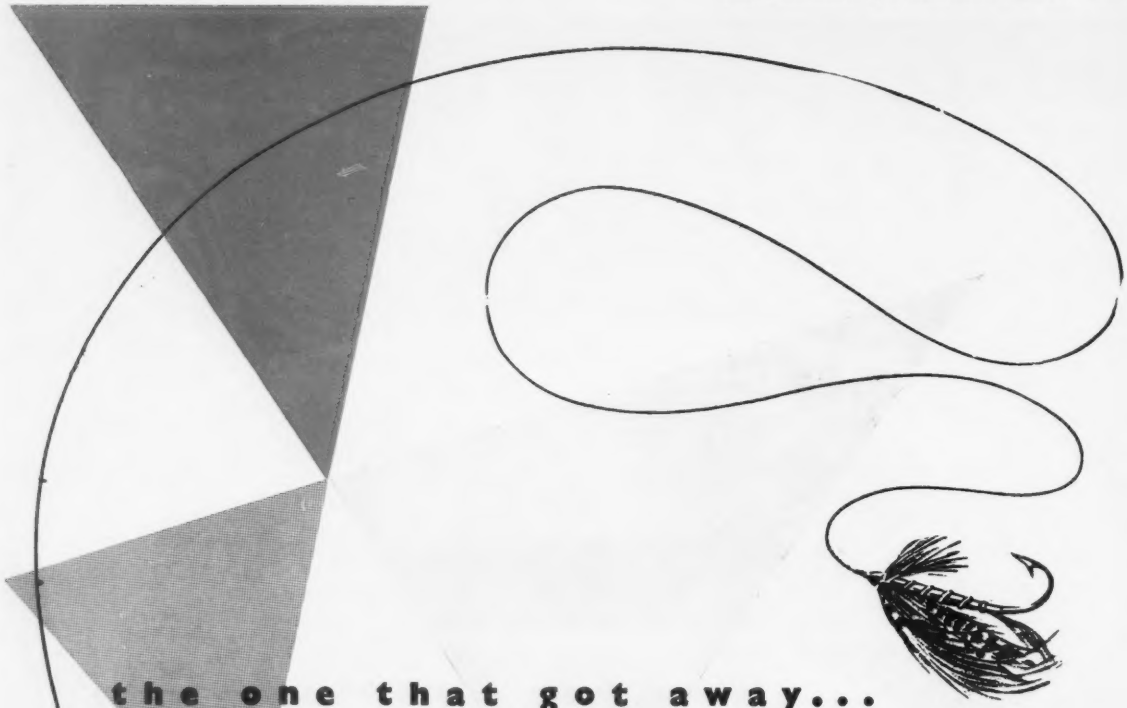

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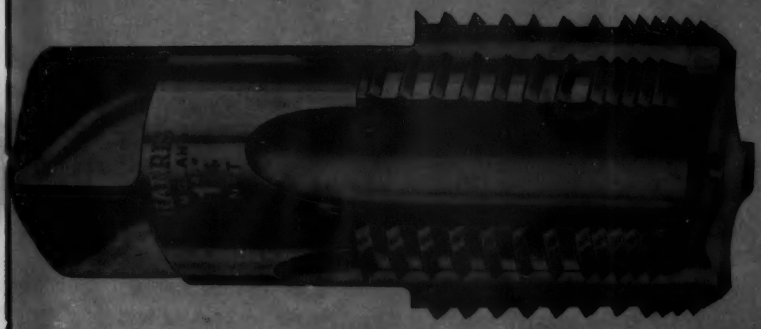

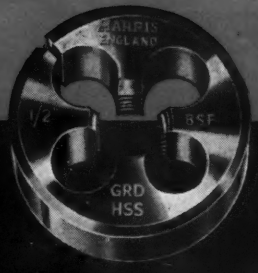

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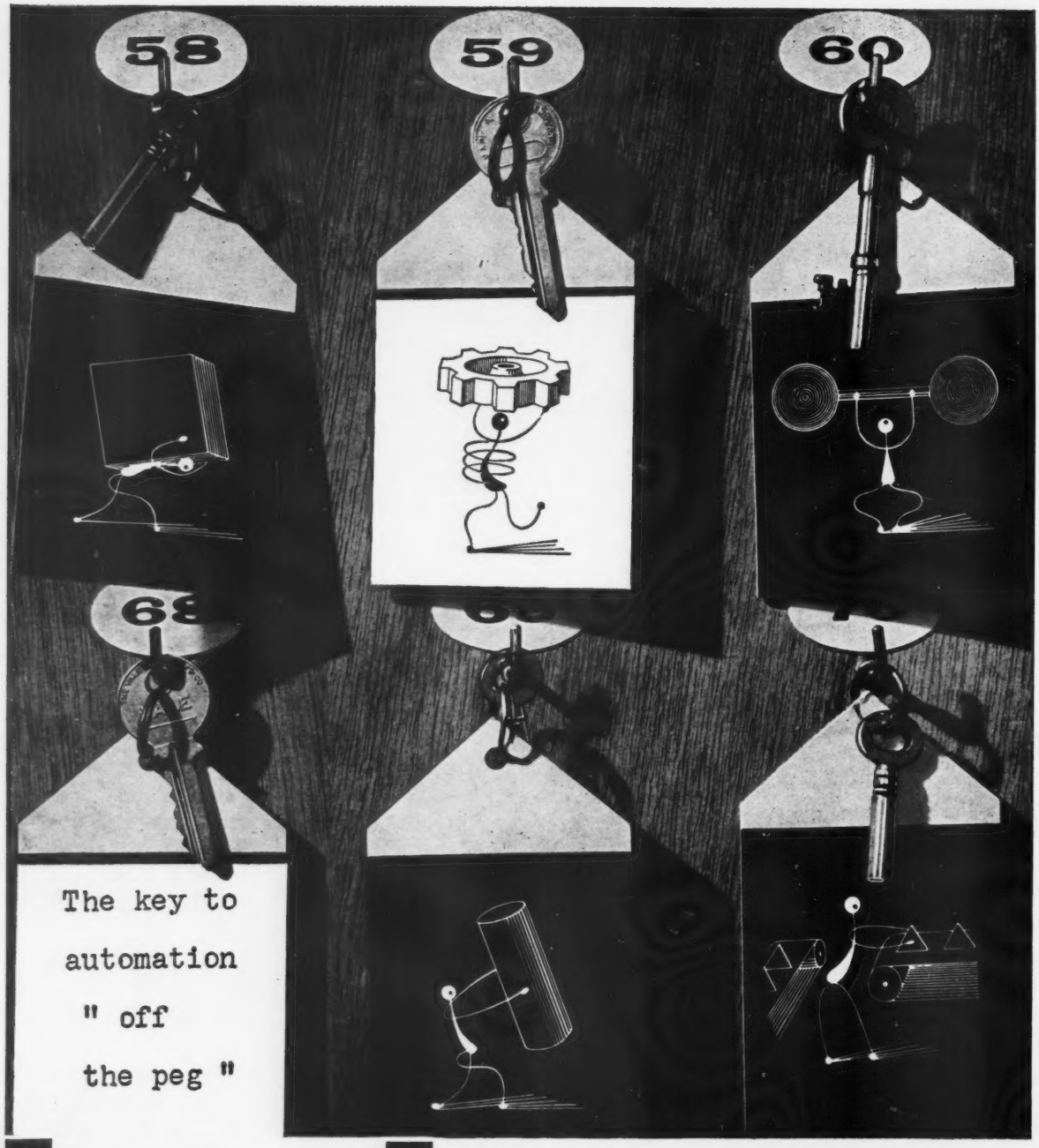

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'Progressive' or 'linked line' or 'off the peg' automation means basically the same—Hymatic Automation. As far back as 1953 Hymatic were turning out automatic linking devices, units with which you can link standard or near standard machine tools in your production line. The key is automatic linking equipment: and Hymatic are the people to cut the key. You can learn how automation 'off the peg' can be applied to your production line in a booklet called 'Hymatic Automation'. It describes automatic linking devices and other automatic work handling equipment. Send for a copy to the Hymatic Engineering Co, Ltd, Redditch, Worcestershire.

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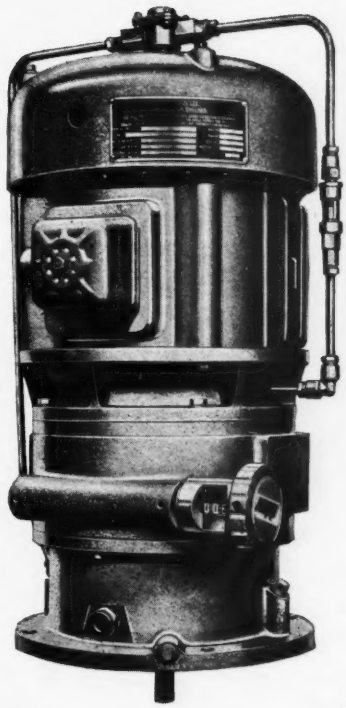

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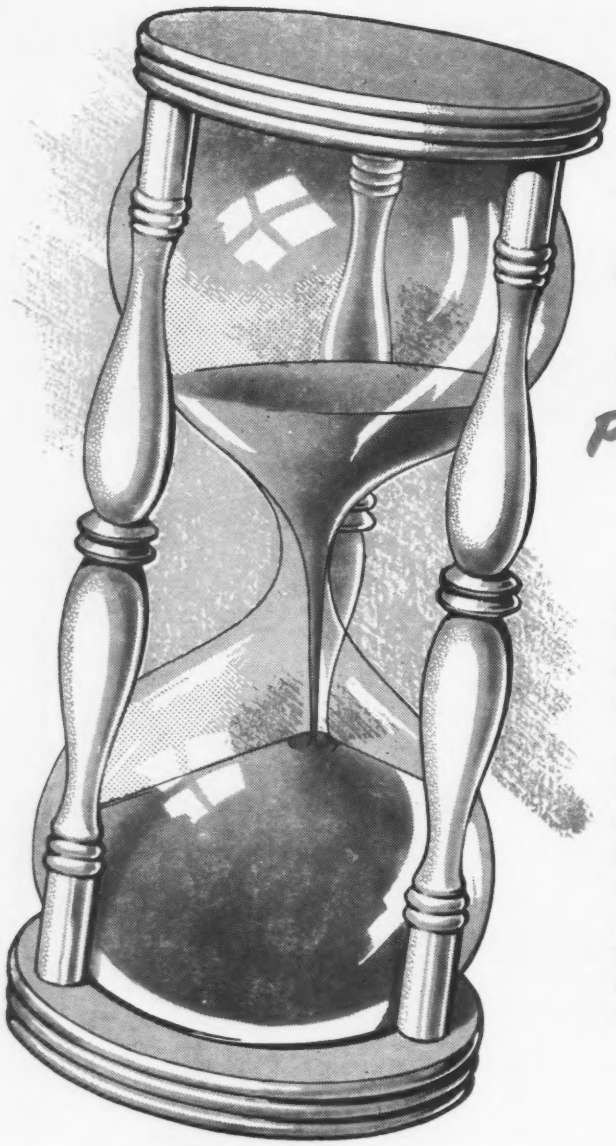

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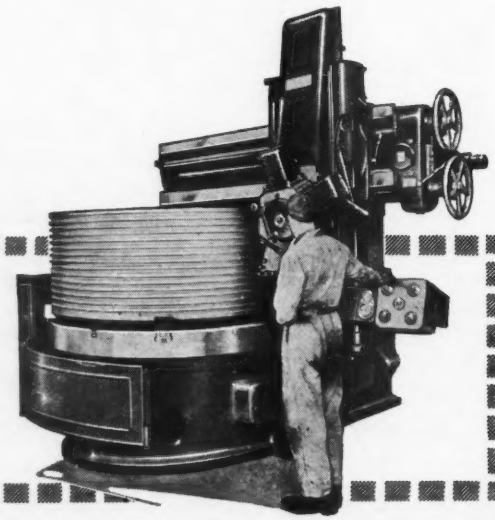

The illustration shows a Webster and Bennett 60″ Boring and Turning Mill at the Bradford Works of Crofts (Engineers) Ltd., machining a 60″ diameter vee groove pulley with a face width of 26″ having 18 grooves 1¼″ wide by 1¼″ deep.

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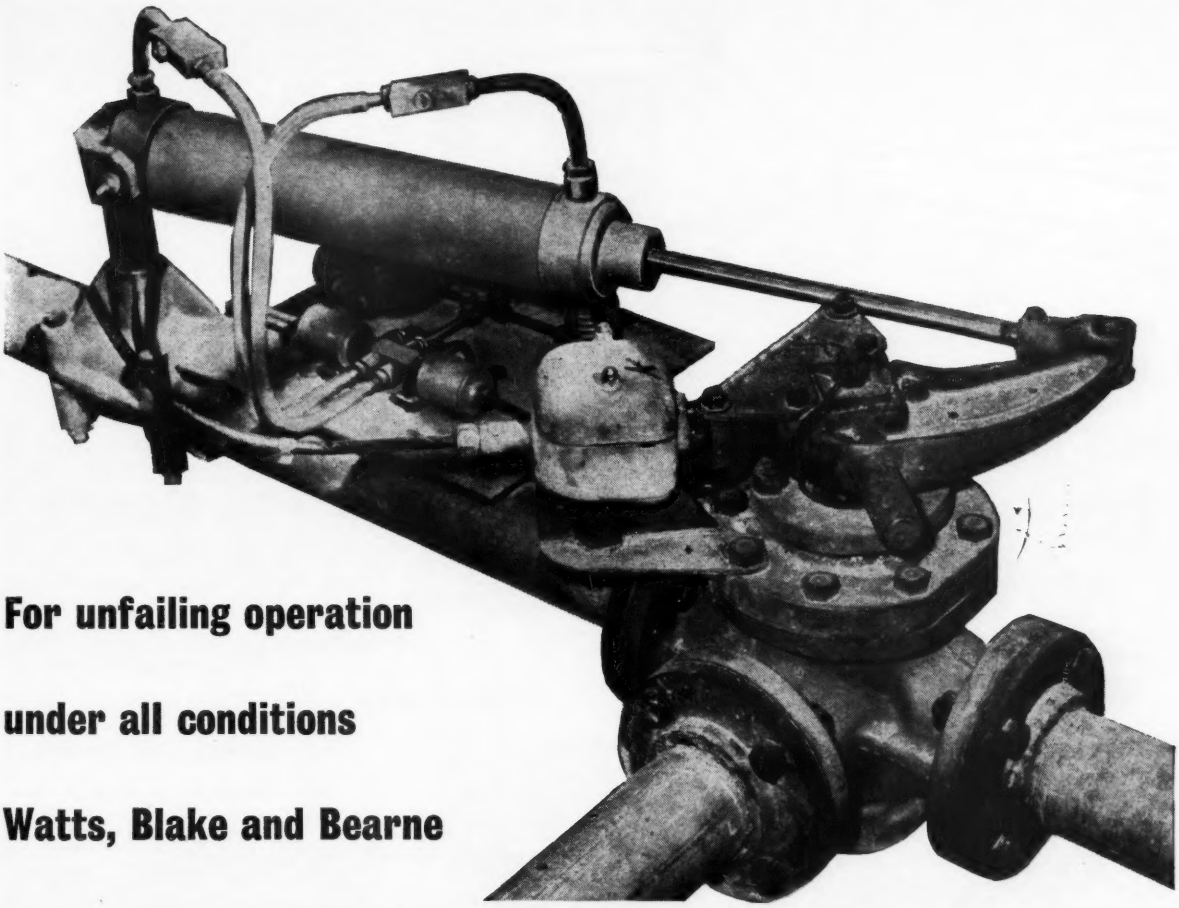

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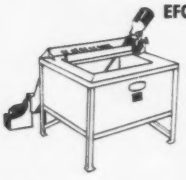

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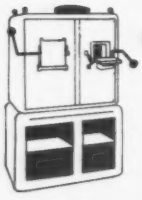

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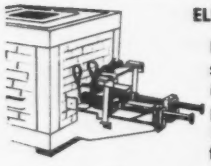

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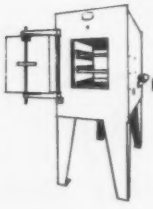

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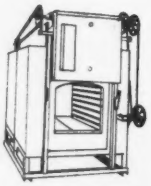

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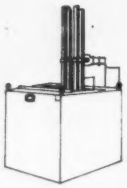

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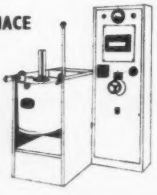

with interchangeable pots for processes from 600 to 1350°C. for small outputs.
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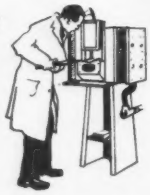

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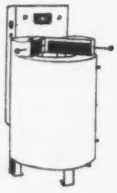

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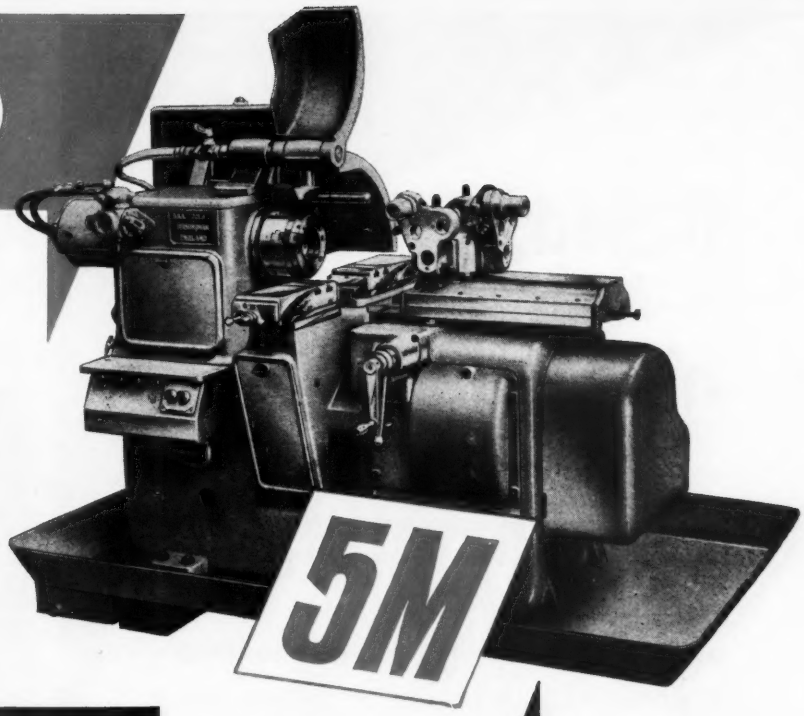

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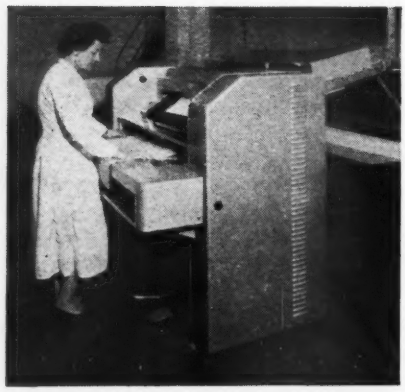

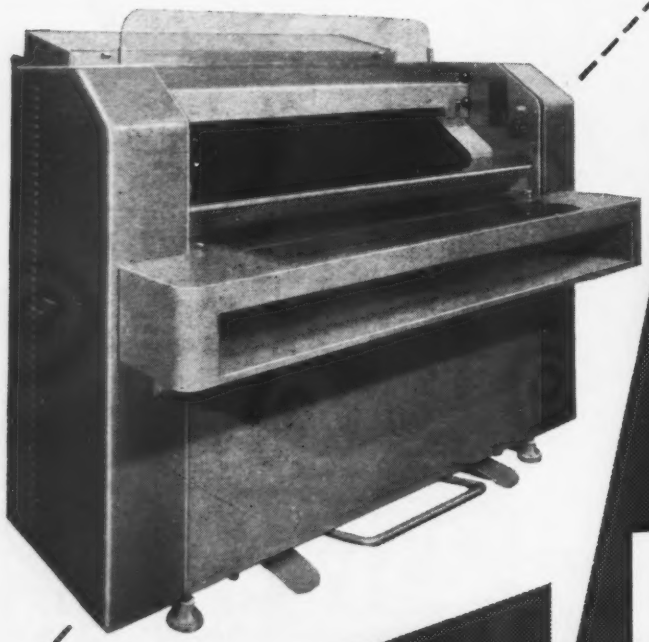

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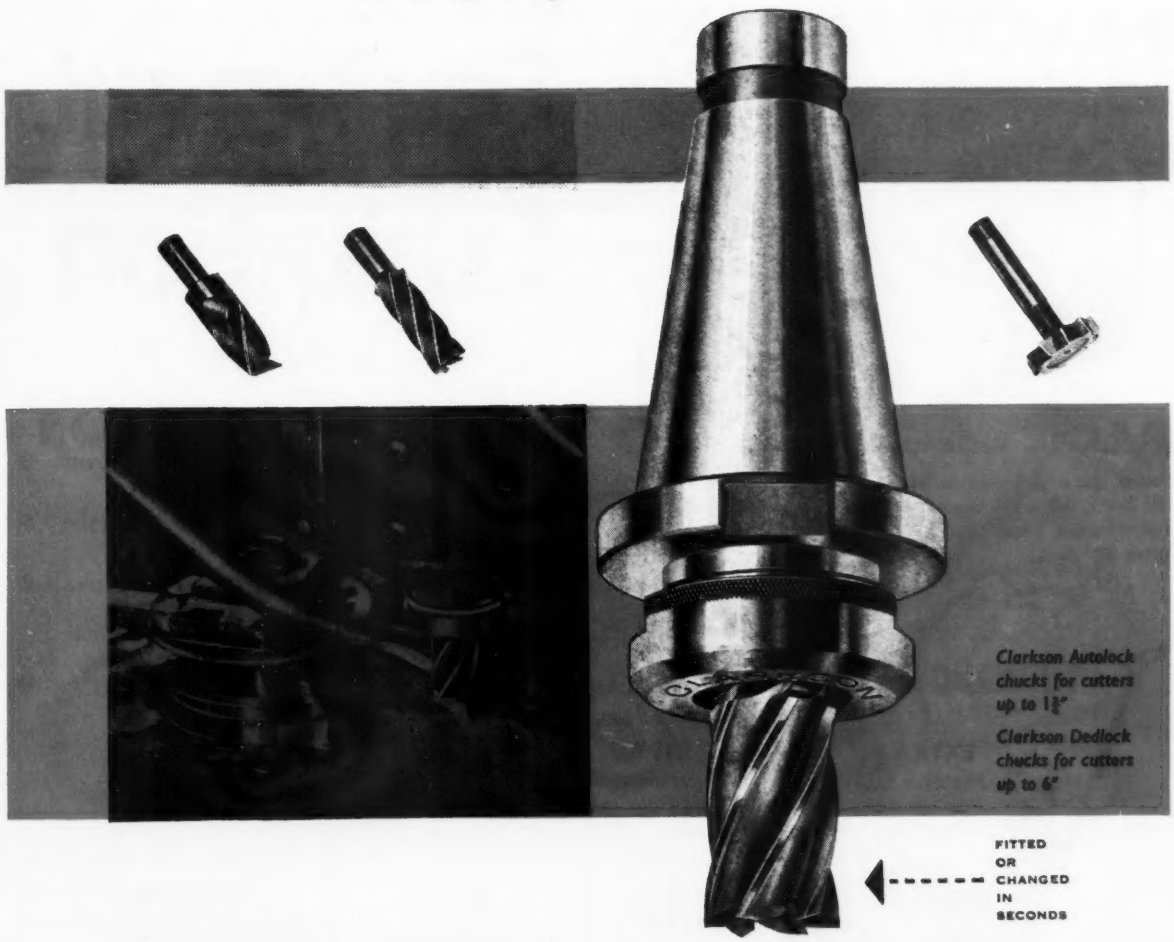

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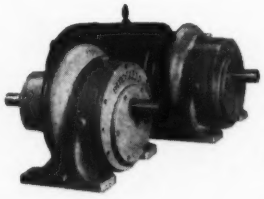

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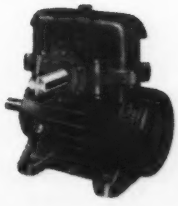

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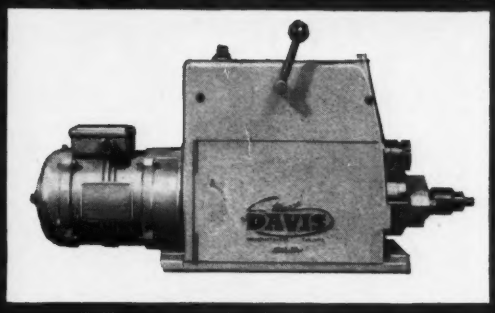

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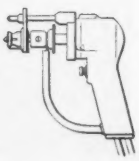

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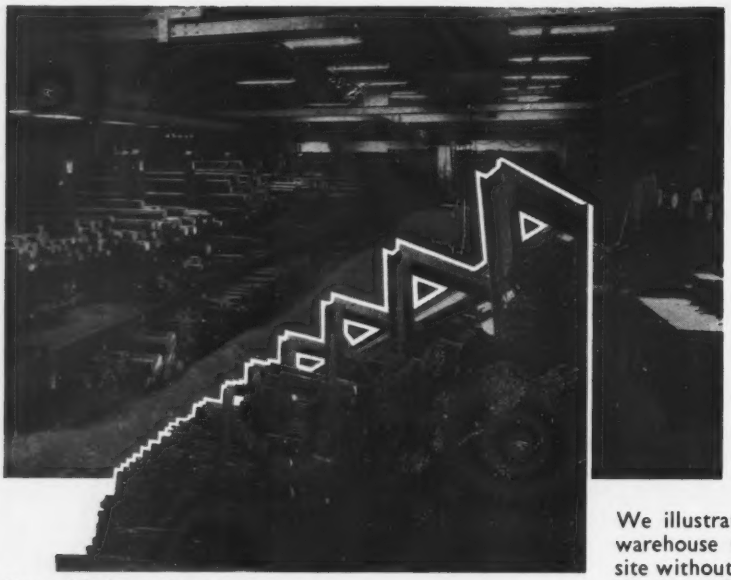

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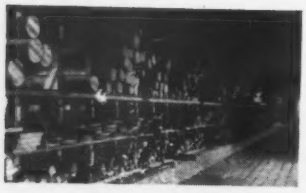

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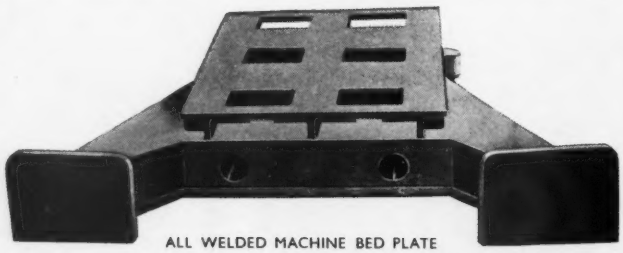

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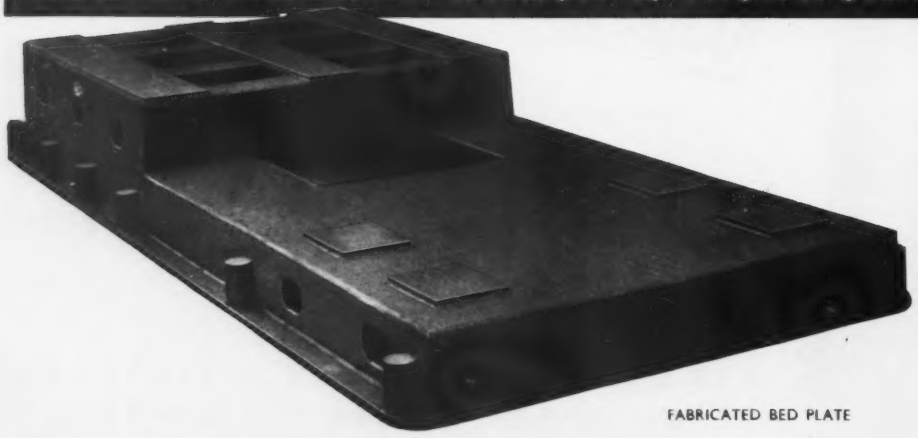

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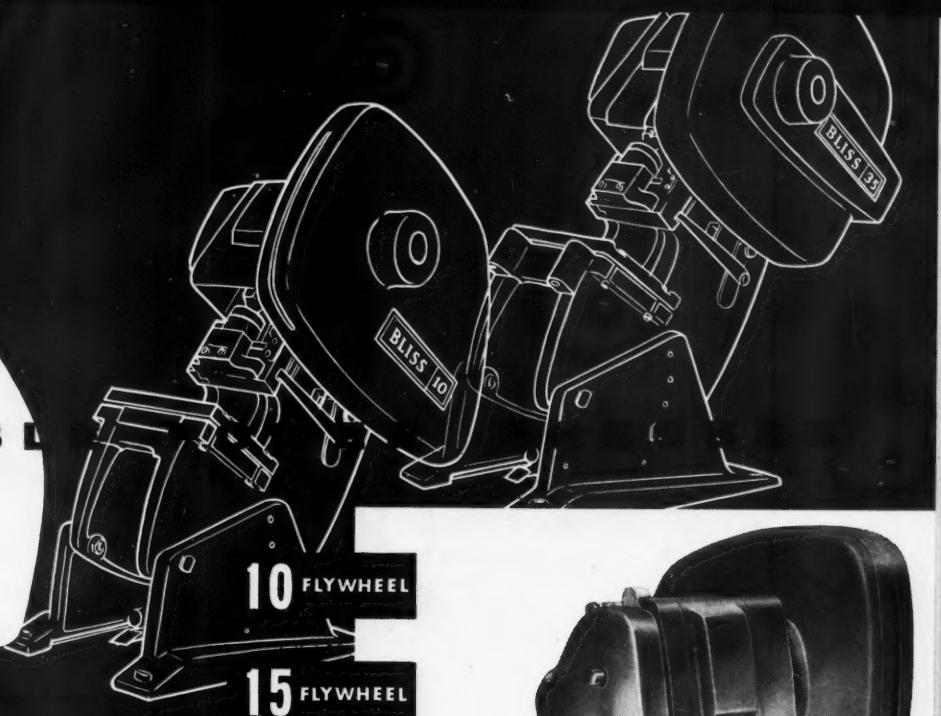

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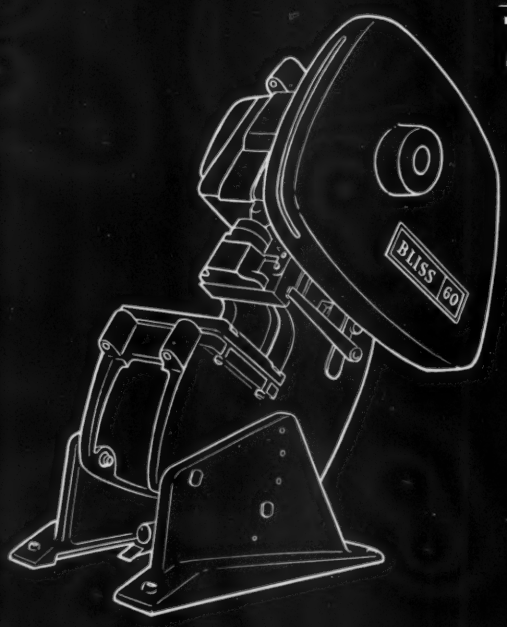

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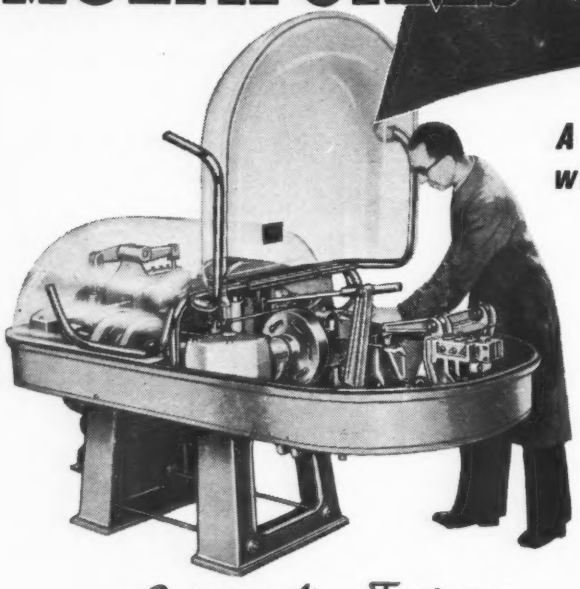

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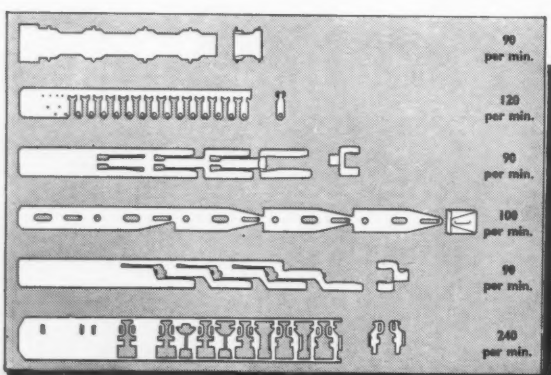

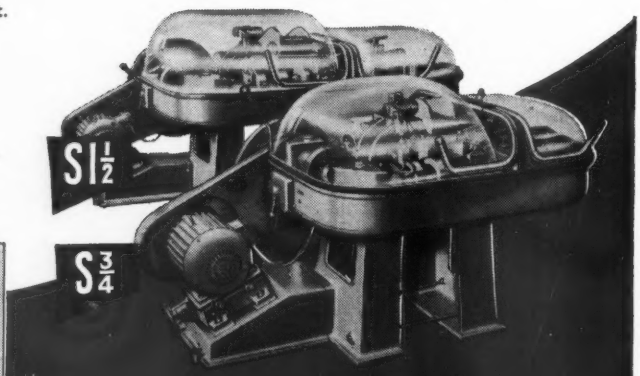

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the possibilities of thermonuclear power and its significance for Australia

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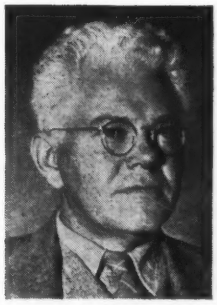

presented to the
Adelaide Section of the Institution
on 4th November, 1958
as the third
JAMES N. KIRBY PAPER

IN September last, I was privileged to lead the Australian delegation to the Second International Conference on the Peaceful Uses of Atomic Energy, in Geneva. Three years earlier I had been a member of the Australian delegation to the first such Conference. Both Conferences were held under the auspices of the United Nations Organisation and were organised superbly. The earlier gathering had been the first occasion upon which the nations shared the results of their work in the industrial applications of nuclear energy, and each session brought revelations of great interest. There was an atmosphere of great excitement about the proceedings. A remarkable feature of the Conference was that it revealed very close similarities between the developments in the different countries, although these were carried out without knowledge of one another's programmes and achievements. An atmosphere of great optimism pervaded the first Conference. Those present were convinced that very rapid progress would be made towards making nuclear power available at costs competitive with the cost of power from coal and oil.

At the second Conference a great deal of information was exchanged, but the atmosphere was very different. In the first place, the very friendly spirit of rivalry and the easy informal nature of contacts outside the lecture rooms, were not reproduced. The Russian delegation was much more stiff and formal and it was almost impossible to have the individual discussions which are so much more important than the actual proceedings of any international conference. The Western governments and industrial firms were reluctant to give details of some processes, or of fuel elements and so on, when it was thought that commercial advantage would be secured by secrecy. Far too many Papers, approximately 2,250, were read to audiences too large for discussions to be profitable. There were too many cocktail parties and dinners given by delegations, and the entertainment provided as advertisement by some industrial concerns was too lavish to be comfortable for the recipients.

Two exhibitions were organised for the period of the Conference. The first was a series of national displays in a very magnificent temporary Exhibition Hall erected in the grounds of the United Nations Palais des Nations. Here, the American display stole the show completely. A series of models and of actual research equipment in operation were shown, with research workers themselves present to explain what was happening in fusion research in the United States. This was a magnificent display at which those of us who were interested in the thermonuclear matters spent many instructive hours.

The second exhibition was held in the Exhibition Hall in the City and consisted of displays by industrial concerns of all kinds whose products were used in the application of nuclear energy. This again was on a singularly lavish scale, one American firm even importing young Parisian fashion models to add glamour to its exhibit ! Doubtless this industrial exhibition was of considerable importance to those actually engaged in the development of practical reactors and associated equipment, but it was of little importance for the solution of the basic problems of atomic energy.

power from uranium

The optimism about the economic aspects of nuclear power derived from the fission process, which was a feature of the first Conference, was less apparent three years later. While there is a universal conviction that economic industrial power will one day be obtainable from the fission of uranium and thorium nuclear fuels, the time when cheap atomic power will replace power from conventional fossil fuels has receded into the future. Only in countries such as England, where coal is expensive, where there is no indigenous source of oil or natural gas, and where hydroelectric power is scarce, does it seem that nuclear power can make a significant contribution to industrial power resources in the near future. The natural uranium, graphite-moderated reactor, with carbon dioxide as the heat-transfer medium, has been developed very successfully in Britain. Following the initial success with the Calder Hall plant, various improved versions are now in process of construction by a number of groups of companies. So far as can be foreseen at present, these newer power stations will operate as base stations at high load factor, to produce power at a little less than 1d. per unit — 0.8d. is often quoted. This power will be a little more expensive than power from coal, but it will meet the rapidly increasing demand for electric power when expansion of coal output seems difficult or impossible. The capital cost of nuclear power stations is much greater than that of conventional plant. It is these capital costs which inflate the resultant cost of power, for the costs of the actual nuclear fuel consumed are negligible in the British plants.

The Canadian nuclear energy programme has been based upon the use of natural uranium with a heavy-water moderator. The heavy water is far more expensive than the graphite moderator used in the British reactors, but because it is more effective and efficient, only tens of tons of heavy water are required for a reactor in which hundreds of tons of graphite would be employed, and the physical size is much smaller. Although a great deal of experimental work has been done in Canada, which has led to justified optimism, and a power plant is now under construction, it is too early to judge whether natural uranium, heavy-water moderated reactors will prove economic sources of industrial power.

use of enriched fuels

Development of power reactors in America and Russia is based almost wholly upon the use of enriched fuels, i.e., of uranium in which the content of the fissionable isotope of mass 235 has been increased greatly. Such enriched uranium is produced in isotope separation plants, which are very expensive in capital cost and to operate. Except where these costs can be offset against military uses of atomic energy, they result in nuclear fuel costs which are much too high to be competitive with conventional fuels. Their use is confined to special purposes, such as submarine propulsion, where cost is of no importance, or for purely experimental reactors.

The direction of further development of fission reactors is likely to be principally towards the use of higher temperatures. This means the substitution of oxide or carbide fuel elements for the more fusible metallic elements now generally in use, together with the development of better " canning " materials than the aluminium, magnesium or zirconium preferred at present.

A major reason for the complex design of fission power reactors is the radioactive nature of the fission products, the " ashes " of the nuclear fuels. The steps necessary to contain these fission products in the nuclear fuel elements by " canning ", the elaborate precautions needed to protect workers from the highly radioactive fuel elements on removal from the reactors, the complex chemical plant needed to process fuel elements and remove the radioactive nuclear " ashes ", and the difficult problem of safe disposal of these fission products, all add greatly to the capital and running costs of a fission power plant.

The danger of accident with nuclear reactors is not negligible, as has been illustrated dramatically by accidents in England and Canada which resulted in costly shut-down and decontamination procedures. While it is true that no real danger to life resulted from these accidents, the possibility of such incidents leads to elaborate and expensive precautions in the design and location of power-plants.

This is a very sketchy discussion of the present status of nuclear reactors as sources of industrial power. The position is very complex; great technological ingenuity is being used in development and enormous resources of Government money are being poured into the solution of the many problems which must be overcome before nuclear power is freely available at reasonable cost. However, given the scientific and technological effort, there is little doubt that in time all the difficulties will be surmounted. Meanwhile, it would be irresponsible to advocate the large-scale introduction of nuclear power stations in Australia. Until smaller and more flexible power units with reasonable efficiency have been developed successfully, there is no advantage in nuclear power stations for inland Australia, and it is dubious whether, even in South Australia with its meagre coal resources, the introduction of atomic power will be justifiable for some time to come. The Australian Atomic Energy Commission is well aware of these facts and its programme of development is designed to ensure that Australia will be ready to use nuclear power from her uranium when it becomes an economic proposition.

power from hydrogen

It is known that the continual loss of heat by the earth is compensated by the release of energy by radioactive substances in the crust. The small amounts of uranium and thorium, and the far larger quantities of potassium in the rocks, generate enough energy to maintain the temperature gradient in the earth. The energy released in radioactive transformations is, however, totally inadequate to account for the observed constant temperature of the sun.

The identity of mass and energy was one of the significant results of Einstein's theory of relativity. The energy which would be produced by the complete conversion of 1 ton of mass into energy, if that were possible, would be the equivalent of burning about 10 thousand million tons of coal. The sun radiates energy at a rate equivalent to the disappearance of several thousand tons of mass every second. It is thought that this enormous amount of energy is produced by the combination of hydrogen atoms to produce atoms of heavier substances, such as helium, in the central regions of the sun, or of any other star, where the temperature is about 10 million degrees Centigrade and the pressure many millions of pounds per square inch.

An atom of helium is a little lighter than 4 atoms of hydrogen, and if it is formed by the union of 4 atoms of hydrogen the difference in mass would be released as energy. The release of energy resulting from the "fusion" of 1 lb. of hydrogen to form helium can be calculated from the known masses and is about 100 million kilowatt hours. Hydrogen is by far the most plentiful material in the sun and at the required rate of "burning" would serve to keep the sun hot for many thousands of millions of years.

The physical processes by which hydrogen atoms combine to form helium, and subsequently heavier atoms, are relatively slow processes involving the creation and release of positive electrons during collisions. In a nuclear furnace as large as the sun, these very slow processes can release sufficient energy to maintain themselves, but for the successful release of fusion (thermonuclear) energy for industrial purposes, it is necessary to make furnaces of more modest dimensions. Consideration of the problem shows that it will never be possible on earth to bring about the fusion of ordinary hydrogen so as to release useful power.

isolation of "heavy water"

In 1933, Professor G. N. Lewis, the distinguished physical chemist who was among the first to isolate "heavy water" by electrolysis of ordinary water, visited the Cavendish Laboratory, Cambridge, where I was then working with Lord Rutherford, the father of nuclear physics. Professor Lewis presented to us two tiny glass ampoules, each containing one drop, that is about one-fifth of a cubic centimetre, of heavy water. Ordinary water is oxide of ordinary hydrogen, H_2O, but the hydrogen in natural water contains always about one part in six thousand of another variety, or isotope, of hydrogen, the atoms of which are just twice as heavy as atoms of ordinary hydrogen. This heavy hydrogen, or deuterium, can be concentrated in a variety of ways, the simplest of which is electrolysis in which the ordinary hydrogen escapes preferentially at the cathode. Thus, it is possible to obtain pure heavy water, or deuterium oxide, which looks and behaves exactly like ordinary water except that it is about 10% denser. The deuterium (heavy hydrogen) in this heavy water can be set free by chemical methods and can be used in place of ordinary hydrogen for any purpose.

Since the discovery in 1932 by Cockcroft and Walton, also in the Cavendish Laboratory, that the cores, or nuclei, of ordinary hydrogen, which have been called protons by Rutherford, could be accelerated artificially to speeds where they produced nuclear transformations in light atoms, great interest had centred upon the possibility of using the nuclei of heavy hydrogen (deuterons) as atomic bombarding bullets. Naturally then, we immediately made heavy hydrogen from the drops of heavy water given us by Professor Lewis and used it in our high voltage equipment to bombard various elements with deuterons. A variety of interesting new transformations was observed, but by far the most important and exciting were the two nuclear reactions which occurred when deuterons were used to bombard a target containing heavy hydrogen itself.

In the collision of a deuterium nucleus with another such nucleus three different processes were shown to take place. In the first and most probable case the

collision is elastic, like that between two billiard balls, and the two particles share the energy and momentum, going off at right-angles to one another. In the second case the particles which separate are not the same as those which collided, the nucleus of an atom of triply heavy hydrogen, or tritium, escaping opposite a proton, energy of approximately 4 MeV (millions of electron-volts) being liberated in the process. In the third, and equally probable reaction, the products are a nucleus of triply heavy helium (^{3}He) and a neutron, which is a particle without electric charge but with a mass just a little greater than that of a proton. These reactions may be written :

$$^2_1D + {}^2_1D \rightarrow {}^3_1T + {}^1_1H + \text{energy}$$

$$^2_1D + {}^2_1D \rightarrow {}^3_2H + {}^1_0n + \text{energy}$$

The energy released in the two cases is approximately the same. These were the first occasions in which the two new nuclei of mass 3 had been observed, so that the experiments were exciting.

A significant feature of the deuterium reactions was that they could be observed at bombarding energies far less than those necessary to bring about any other known transformation with charged particles. Since then, and following the production after the War of significant quantities of tritium in nuclear reactors, it has been found that the nuclear reaction of tritium with deuterium takes place even more readily, yielding ordinary helium of mass 4 and a neutron :

$$^2_1D + {}^3_1T \rightarrow {}^4_2He + {}^1_0n + \text{energy}$$

In this case the energy released is about 17 MeV. Helium of mass 3 will also react with deuterium to give helium of mass 4 and a proton :

$$^3_2He + {}^2_1D \rightarrow {}^4_2He + {}^1_1H + \text{energy}$$

but in this case the probability of reaction is much smaller.

It is seen that the nuclear interaction of deuterium with itself leads, in the end, to the production of helium of mass 4 with the release of considerable amounts of energy. Calculation shows that in this fusion process about three times as much energy is released by 1 lb. of deuterium as is released in the fission of 1 lb. of uranium. Thus, if a method could be found of bringing about this fusion process in a self-sustaining manner, deuterium should be a better nuclear fuel than is uranium.

Deuterium is a very attractive nuclear fuel for the production of industrial power. An inexhaustible supply of heavy hydrogen exists in the sea, so that whereas uranium and thorium supplies could provide the growing power needs of the world for a few hundreds of years at most, the deuterium in the sea could satisfy all mankind's needs for power for thousands of millions of years. Also, the products of the fusion of deuterium are harmless natural gases and no difficulties of disposal of radioactive wastes need ever occur. The problem is how to bring about a self-sustaining fusion reaction.

As the temperature of a gas is increased, its atoms collide with one another with greater and greater energy. Thus, by heating deuterium to a great enough temperature it should be possible to initiate a fusion reaction, and if the pressure and volume of the gas are great enough to absorb the energy released, the high temperature should be maintained by the reaction. Unfortunately, the temperature required for this to happen is of the order of 100 million degrees Centigrade, about 10,000 times hotter than the surface of the sun or 10 times hotter than the centre of the sun. Enormous energy must be poured into a gas to heat it to this temperature at which all known substances are in the vapour state, so that no material box could enclose so hot a gas.

" clean " hydrogen bombs

In the explosion of an ordinary fission-type atomic bomb, temperatures of hundreds of millions of degrees and pressures of millions of pounds per square inch are produced for a few millionths of a second. It has proved possible to use a fission bomb to heat deuterium to temperatures at which fusion reactions take place. This is the principle used in the hydrogen bomb. Bombs in which the majority of the energy is released in thermonuclear fusion processes have been called " clean " bombs because there are very few radioactive by-products. Hydrogen bombs releasing energy equivalent to the detonation of 20 million tons of TNT, and able to devastate the largest city, have been tested. Dr. Teller has suggested that if such weapons were detonated deep underground, the heat produced would remain trapped there for a very long time and could be extracted by suitable methods and used to generate industrial power. However, most scientists who have considered this suggestion have come to the conclusion that it is impracticable and unsafe.

A major portion of the proceedings of the recent Conference in Geneva was concerned with the sharing, for the first time, of the results of attempts made in the various countries to produce thermonuclear reactions under controlled conditions. Certain general patterns of approach emerged from the discussions and a great deal has been learned about the very peculiar properties of hot gases, but there is as yet no evidence that anyone has achieved conditions where a true thermonuclear reaction took place. The most impressive experimental work has been carried out under the auspices of the Atomic Energy Commission in the United States. The greater part of the American exhibit at the scientific exhibition at the Palais des Nations was devoted to work on fusion, the actual working equipment having been transplanted from the various laboratories in the United States together with the research workers who had

conceived it. The ingenuity displayed was tremendous and the basic understanding of many of the methods was apparent. From Russia came a scale model of one piece of apparatus and accounts of rather similar work on a smaller scale and without the variety of methods. Britain contributed the story of "Zeta" and showed a model of the equipment. Experimental and theoretical investigations were described from Sweden, Denmark, Germany and France. For the scientist these discussions and exhibits of thermonuclear work were the most rewarding sections of the Conference.

magnetohydrodynamics

At very high temperatures the single electron of any hydrogen atom is shaken free from the nucleus and the gas then consists of a mixture of free electrons, carrying negative charges of electricity, with free hydrogen nuclei, carrying positive charges. Such a mixture of charged particles is electrically neutral as a whole, and is called a plasma. The most complete consideration of matter in this state had, until recently, been developed by astrophysicists who sought to explain the structure and properties of stars. A new branch of physics, magnetohydrodynamics, grew up to give a quantitative model of the complex phenomena accompanying motions of plasma, and these ideas have proved of great interest to workers in the thermonuclear field.

In order to heat a gas to a very high temperature in the laboratory, some method must be found to pour energy into it at a sufficiently high rate to overcome losses of heat by radiation and by conduction to the walls of the containing vessel. Three general methods have been used. The first is rapid adiabatic compression of the gas as used in the diesel engine to heat the air to the ignition point of the fuel oil. In order to reach the temperatures of tens of millions of degrees required to initiate fusion reactions, the gas must be compressed to such high pressures that no container would withstand the stress. The limitation is set by the limited strength of available materials, except in the case where the compression is in a shock-wave of enormous amplitude which can normally be produced only by detonation of an atomic explosive.

The second method for heating a gas to very high temperatures is to pass through it an electric discharge carrying a current of millions of amperes. Currents of this order of magnitude can most readily be obtained by the discharge of electrical capacities of minimum inductance arranged in a circuit of low impedance. Such capacitor banks are very bulky and extremely expensive. At high temperatures a plasma is a far better conductor of electricity than copper, so that even at currents of millions of amperes it is difficult to dissipate the necessary large energies in the plasma to heat it to millions of degrees.

The third method is to pour energy into the gas as kinetic energy of beams of accelerated charged particles, produced externally, which share their energy in collisions with the ionised gas. The problem in this method is that it is extremely difficult to put the energy into the gas very rapidly and it is necessary to hold a stable plasma in a container for comparatively long periods of time.

All three methods depend upon successful containment of the plasma and all have failed so far because the problem of containment has proved insoluble by the means employed. This difficulty can be illustrated by considering heating by passing an electric current through the plasma — ohmic heating. Everyone is familiar with the fact that a wire carrying an electric current is surrounded by a magnetic field, which can be visualised as lines of magnetic force in the form of circles about the wire. These lines of magnetic force are in a state of tension and so exert a pressure on the wire of radius r given by:

$$P = \frac{i^2}{2\pi r^2}$$

If the current is 1 million amperes and the radius of the wire 1 mm, P is about 3 million pounds per square inch. Such forces are very small at the currents which can be carried in practice by wires, before they fuse, but a plasma can carry large currents quite easily. Hence, a plasma which carries a current of a million amperes is very strongly compressed in a radial direction perpendicular to the direction of flow of the current. This "pinch" effect can readily be observed in a glass tube containing a gas at low pressure through which pulses of increasingly heavy current are passed. At first the discharge fills the tube, but when the current reaches hundreds of thousands of amperes it separates from the walls and flows as a streak down the centre of the tube. The plasma is confined by its own magnetic field and hence can be heated further by increasing the current, without melting the walls of the tube or shattering them because of the high pressure exerted by the heated gas.

presence of local instabilities

These very promising results have not, however, led to success. The simple linear pinch in deuterium does yield some neutrons, but the presence of directional effects makes it certain that these arise from collisions of deuterons accelerated in locally existing electric fields. More careful study of the electrical and optical properties of the linear pinch reveals local instabilities which cannot be removed by any external magnetic fields which can be applied. Electrode effects have been eliminated by making the plasma the secondary of a transformer — the toroidal electrodeless pinch — but, as shown with the British "Zeta" experiment, the results are the same. It seems that a plasma does not behave as an electrically neutral medium as is assumed in magnetohydrodynamics, but that it generates microscopic regions of gross charge separation and of local ion acceleration, leading to instabilities which prevent further rise in temperature.

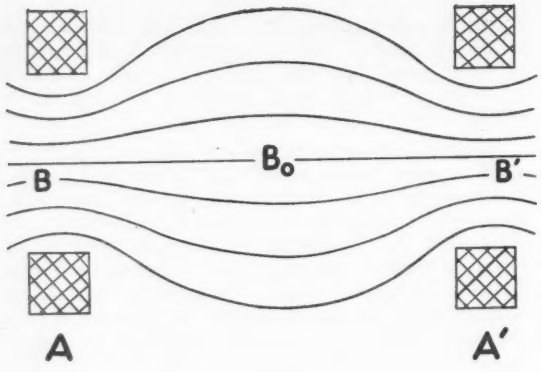

Fig. 1.

Realisation of this problem of the inherent instability of a plasma has led to many investigations, both theoretical and experimental, of the fundamental properties of a gas at very high temperatures. It has also led to attempts to visualise other forms of containment than the self magnetic field. Among such containment systems is the "mirror" magnetic field illustrated in Fig. 1.

The general principle is that a disposition of current-carrying coils AA′ produces a barrel-shaped magnetic field as illustrated. The strength of the field at BB′ is greater than it is at B_0. Such a magnetic field has the property that charged particles created in a plasma at B_0 cannot escape unless their energy is above a value depending on the strength of the field, or unless they move out along the axis. Charged particles spiral along the lines of force of the field, but are reflected back at the stronger fields near the ends of the containing region. A plasma in the region B_0 can be compressed by suddenly increasing the magnetic field and its temperature thereby raised, or charged particles can be fired into the region from outside and are trapped if they lose energy by collision inside the region. Many variants of this kind of system are under trial in America and Russia, but so far no positive results have been reported.

a general picture

What has been said in the foregoing paragraphs gives a general, but by no means exhaustive, picture of the state of thermonuclear investigations today. The problems are fascinating and the work is significant in the understanding of stellar matter as well as in the approach to power from the fusion process. In Canberra we are planning experimental work using the power impulses from our homopolar generator to heat a plasma, and in physical laboratories all over the world the problem is receiving increasing attention since the ending of secrecy. Thermonuclear power will not be obtained easily and it may well be 10 - 15 years before the basic difficulties are overcome. However, there is no physical reason why the task should be insuperable. Experience shows that what is basically feasible is always realised in time, and in this case the prize of cheap and everlasting power is so attractive that immense resources will be devoted to the problem. Personally, I believe that an answer will be found and that ultimately mankind will derive power wholly from thermonuclear reactors.

Thermonuclear power is likely to be available as heat which can be transformed into electric power by means of heat-engines and dynamos. There is some hope that it may prove possible to transform part of thermonuclear energy directly into electric power, but this hope is rather slender. In either case, the power will reach the ordinary industrial and domestic consumer as electric power. He will notice no difference except perhaps that costs will fall and reliability will be greater. However, it is worth examining other and bolder ways in which the coming of thermonuclear power could be of great significance for Australia and for the rest of the world.

Perhaps the greatest boon to mankind would arise from the fact that every nation, without exception, would enjoy the same access to the raw materials of thermonuclear power. The water available to every country would supply deuterium sufficient to generate all the power which could conceivably be required. Where power is concerned there would no longer be "haves" and "have nots", and one of the basic causes of war would disappear.

Australia's greatest need

Australia lies in the belt of latitude where rainfall is low, and so much of her area is arid. Reliable supplies of fresh water for irrigation are her greatest need. Strangely enough, despite this obvious fact. less money and effort are devoted to research and development in this field of hydrology than in almost any other part of Australia's economy. Probably, this is because water problems belong to the states and the Commonwealth is specifically prevented from considering water as a national responsibility. This picture may change completely when the thermonuclear power is available. I like to picture thermonuclear power stations on the coast, the power from which is used in various ways to distil sea water and to pump the resulting fresh water inland for use in irrigation and domestically. At the same time the power station would separate its own deuterium fuel from the water. Such large-scale distillation would produce large quantities of salts from which a chemical works would make fertilisers and other valuable products with the aid of the power available. Electricity would go inland along power lines so that air-conditioning and all the amenities of civilisation would be enjoyed by those using the water supplies. Mineral industries would arise where now it is uneconomic to establish mines. Australia, in fact, would become a home for hundreds of millions of people instead of for tens of millions only.

(*concluded on page* 180)

production of printed circuit cards to be used on electronic equipment for telecommunication projects

a thesis by G. LAWRENCE, A.M.I.Prod.E.

THE use of printed circuit wiring in telephone exchange equipment is at present confined to experimental electronic exchanges and to the provision of supplementary equipment for already established exchanges in this country and overseas.

For instance, routing equipment in certain exchanges is now being converted to electronic switching systems and the necessary wiring is being printed on synthetic resin-bonded paper cards assembled into frames or " books ", which are packed into equipment racks on suitable twin rails running from front to back of the racks.

The replacement of pages or books is easily effected by sliding the unit or book from the rack and either changing the faulty card or, if need be, the complete unit.

The advantages gained by the use of printed circuit cards in the order of their importance is :-

1. Cheapness in wiring and assembly of components once an automatic line has been established, i.e., automatic feeding of components to cards and dip or "fountain" soldering of component wires to the copper track.
2. The electronic system of switching, as opposed to the use of electro-mechanical relays, has no moving parts and therefore it is anticipated that greater service reliability will be achieved.
3. Consistency of results. On normal wiring, different operators will produce different results on equipment, whereas using printed wiring the introduction of resistance variables is greatly reduced. Furthermore, no wiring errors can be made once the circuit has been established.
4. It is generally agreed that printed wiring will stand up better to higher temperatures than the conventional type of wiring, but this advantage is doubtful, as temperatures recorded on exchange equipment rarely exceed 41°C.

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Set against the advantages there are certain disadvantages :-

1. There is no appreciable saving in space.
2. It is difficult to trace faults, as the cards are often mounted in pairs with the conductor tracks on the inside.
3. Components are difficult to replace, as the heat generated when unsoldering the components damages the resin bond holding the copper track to the plastic card.

The advantages do outweigh the disadvantages, as it is felt that component and track failures will be so infrequent that it will be an economic proposition to replace whole cards to clear a fault in the switching system.

operational sequence for production of printed circuits

The following section outlines the processes employed and the principles involved in the production of printed circuit cards.

The basic material used is synthetic resin bonded paper sheet, having a layer of electrolytically produced copper bonded to its surface.

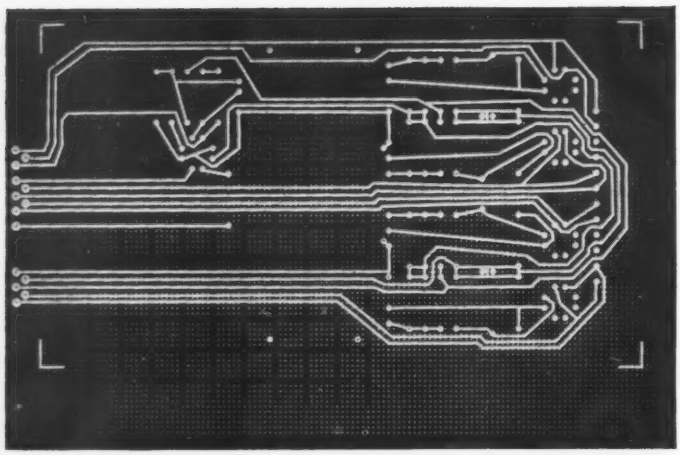


Fig. 1.

1. The copper clad sheet is cut to the required dimensions plus $\frac{3}{8}$ in. all round.

2. Manufacturing holes are jig drilled in the scrap portion of the card.

3. The circuit, evolved from the circuit engineer's diagram, is laid out on a peg-board using metal pegs and adhesive aluminium tape (Fig. 1). The peg-board layout is then photographed.

4. A non-shrink film is now made from the glass negative of the circuit. The film is then positioned on a hand piercing tool and location holes are pierced in it in the same relative positions as the copper clad card (Fig. 2).

5. The drilled card copper surface is now cleaned and coated with a light-sensitive, acid-resisting emulsion (known as the "resist") drained and dried in a low temperature oven. The coated cards are interleaved with tissue paper to protect the prepared surface and stored away from the light until required.

6. The resist coated card is then placed copper side up on a locating fixture having sprung location pins to fit the manufacturing holes in the card and film.

The film of the required circuit is then positioned on top and the loaded fixture secured in a printing frame having a vacuum table, which ensures that the film is in close contact with the copper surface.

The frame is then tilted from the horizontal to the vertical position and the prepared copper surface is exposed to ultra-violet light through the transparent sections of the films (Fig. 3).

7. After exposure the card is removed and placed in a degreasing plant in order to remove the resist unaffected by the ultra-violet light, the hardened resist remaining to protect the copper in the etching process.

8. In order to show up any pin holes, chipped edges, or breaks in the faint yellowish track left on the copper surface, the cards are dipped in a tank of black ink which is slightly solvent with the resist. The inked cards are then rinsed in water to remove surplus ink and stored in racks to dry.

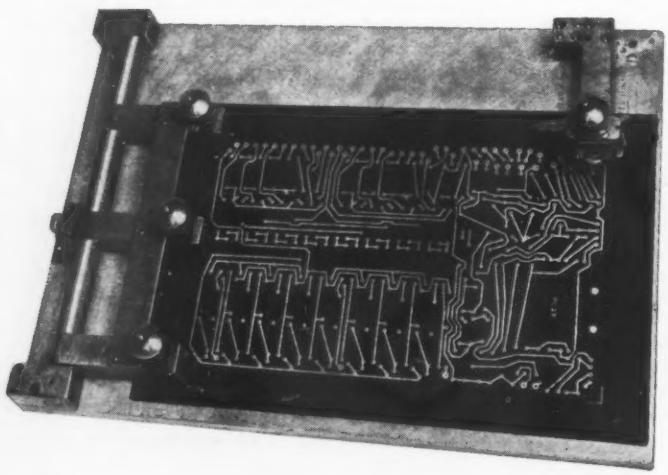


Fig. 2.

After drying, the tracks are carefully examined and any faults shown up by the ink are filled in with bituminous paint, using a fine pencil brush.

9. The cards are now ready for etching and are placed in the etching machine. This machine consists of a plastic container with narrow shelves arranged around the inside walls so that the cards can be disposed around a central hollow cylinder. The cylinder is perforated and the end is immersed in a bath of concentrated ferric chloride at the base of the machine. An electric pump forces the liquid up the central cylinder which is rapidly rotated, thereby spraying the exposed copper surfaces with ferric chloride and thus etching away the unwanted copper (Fig. 4).
10. The etched cards are rinsed and soaked to remove all traces of sludge and iron salts, dried and examined for track continuity.
11. Cards are cut to the required shape either by saw, or routing machine and component, and terminal holes pierced in position.
12. Component wires are now formed, assembled and soldered to the copper track (Fig. 5).
13. The printed circuit card is now complete. It only remains to be assembled on page frames which are mounted into units or "books" and termination joints made from the main cable form, either by wire wrapped joints or conventional soldering methods.

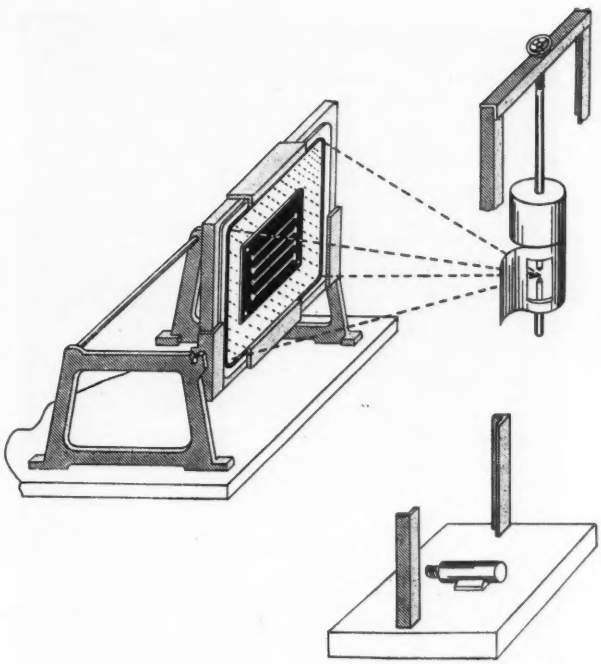


Fig. 3.

preparation of copper laminate cards for printing and etching

In order to produce printed circuits of a sufficiently high quality to meet the requirements imposed by a long service life, it is of primary importance that there is complete freedom from any danger of acid absorption by the exposure of finished size cut edges to the ferric chloride or other acid used in the etching process. This is achieved by allowing a certain margin all round over the finished size of the product. In order to cut down waste a number of laboratory tests have been carried out on cut boards.

These tests took the form of water absorption tests to determine the rate of penetration via various types of cut surface, including guillotined, milled and sawn edges. It was found from these tests that in order to be able to store the rough cut etched product for three weeks before trimming to final size, the minimum border to be cut off finally was .375 in.

No appreciable difference was noted between the results for milled and sawn edges, but it was found that the guillotined edges absorbed water at a higher rate than the first two methods. This was probably caused by the delamination of the material due to stresses set up by the shearing action of the guillotine blade. Some improvement can be obtained in guillotining the product if a low angle upper blade is used and the material is heated to 80°C prior to cutting.

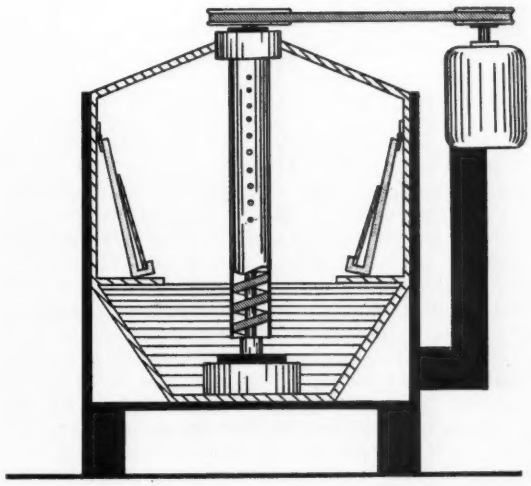


Fig. 4.

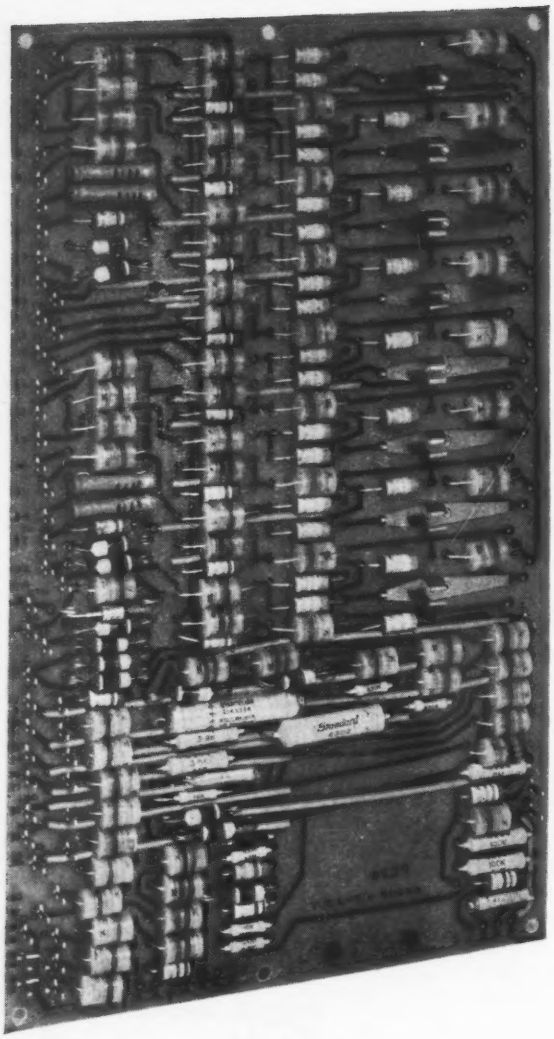


Fig. 5(a).

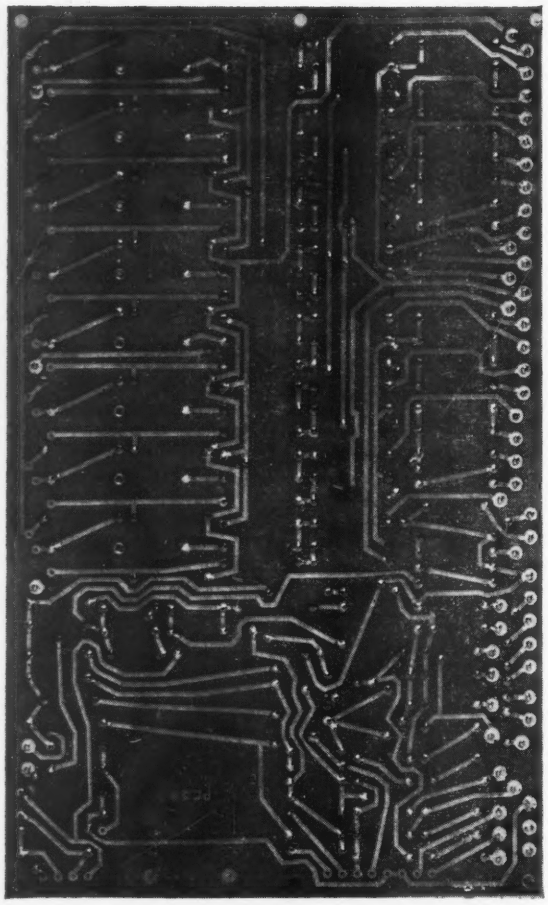


Fig. 5(b).

Some means of orientating the cards with the previously prepared negatives was found to be necessary at this stage. To this end, it was decided to drill register holes in the border or waste portion of the printed circuit card and a drill jig was, therefore, designed with the object of keeping the holes extremely accurate in pitch, and the product perfectly flat, whilst the drilling operation was being performed. As the card dimensions were approximately 14 in. × 7 in., the jig was rather large and it was decided to make it from an aluminium alloy for lightness and rigidity. Steel inserts were incorporated at location positions and was also used for register pins and drill bushes. It was also found necessary at this stage to provide some form of protection against dirt and swarf which would damage the copper faced laminate, and plastic envelopes were used as containers so that the parts would be safeguarded between operations in the machine shop.

layout of printed circuit diagram

Whilst it is true to say that once the circuit has been established one can go on producing circuits without fear of wiring mistakes, it also follows that any circuit changes are viewed with disfavour by the production department. It will be appreciated that the circuit engineer must circumvent any cross-over wiring, which is quite commonplace in conventional wiring work but cannot be accommodated on a printed circuit.

Another limitation in the United Kingdom is the practice of having the track on one side only. Despite these drawbacks, printed wiring and printed circuits (which also have components printed on the cards),

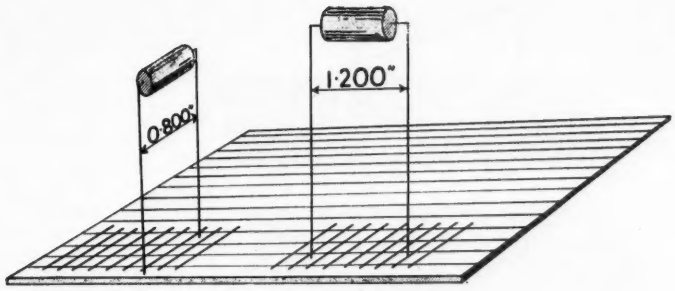


Fig. 6.

are produced for an astonishing variety of electrical and electronic work, ranging from the simple circuit necessary for a motor-cycle headlight to the complicated circuits required for the various types of computer now being produced in Britain today.

There are several methods of translating the circuit engineer's information into a form suitable for the photographic process which is necessary to produce an etched board by the photo-mechanical method. The most useful for very accurate work is undoubtedly the peg-board method.

The other methods in common use are scraper board and Bristol board methods, relying on the skill of the draughtsman to produce an accurate scale facsimile of the circuit. The peg-board method has the advantage that the pitch between component and terminal holes is predetermined by having a board prepared in the toolroom, where all possible modulus holes are jig-bored to very close limits and to a scale twice or four times full size according to the fineness of conductor or component line required, having regard to the reduction range of the camera it is proposed to use.

photographic technique for producing negatives to scale and high definition

The photographic work involved in the production of printed circuits is of a specialised nature and of a very high standard. The negatives produced must retain their original dimensions, the exposed portions must be a dense black and the tracks must be transparent and free from blemish. Special film is used for the negatives to retain dimensional tolerances and care must be taken to ensure that they are handled and hung correctly to avoid diagonal stretch.

A suitable camera for this work would be a 20 in. × 20 in. process camera fitted with a 16 in. wide angle lens and having a suitable range of enlargement and reduction. The camera would have to be mounted on parallel rails with about 16 ft. of travel. A mounting frame for locating a peg-board or other object board is located in front of the camera at a suitable distance from the lens and is illuminated by banks of mercury vapour lights to obviate shadows.

When the peg-board complete with diagram has been set in position, the camera is focused and the image of the circuit appears on a ground glass screen at the rear of the camera. The image is carefully checked and the camera adjusted to ensure that the resulting exposed plate will bear an image of the circuit exactly to size. When the plate is developed a negative is prepared and this is also checked by means of a vernier scale viewed through a microscope.

The completed negative is now located on a hand piercing tool and register holes are pierced in it to line up with the register holes drilled in the copper faced card. These two parts come together on a locating fixture so that the prepared board can be exposed to ultra-violet light. The line up holes in each part ensure that the image will be printed on the card in a fixed relationship to the edges. The holes are also at a known distance from the 0.100 in. modulus grid system so that all subsequent drilling, piercing and cutting operations can be registered from them.

producing accurately-pierced cards from translucent prints obtained from original negatives

The position of the holes in the card must be held to a close dimensional tolerance if all the holes are to appear central in the copper discs which appear at terminal and component fixing points. These holes are on a 0.100 in. grid system which is being widely accepted as a standard. This allows component manufacturers to produce components of a dimension that will allow the component wires to be formed at right-angles to the axis of component and to have a pitch dimension of some multiple of 0.100 in. (Fig. 6).

It has also been accepted that the minimum diameter of hole be 0.052 in., but there are signs that some designers, particularly on miniaturised equipment, are going below this diameter and are also working on a modulus of 0.025 in.

The method employed to produce the necessary holes in printed circuit cards is determined by the quantities required. Assuming that the circuit to be produced is part of a radio or television receiver, it would be reasonable to suppose that thousands per week of one type would be required for a limited period, and at an early date. In this case it would obviously be advantageous to pierce all holes and cut-outs at one hit, using a simple piercing tool fitted with a spring stripper. It would be necessary to heat the laminate in a muffle furnace or hot plate to a

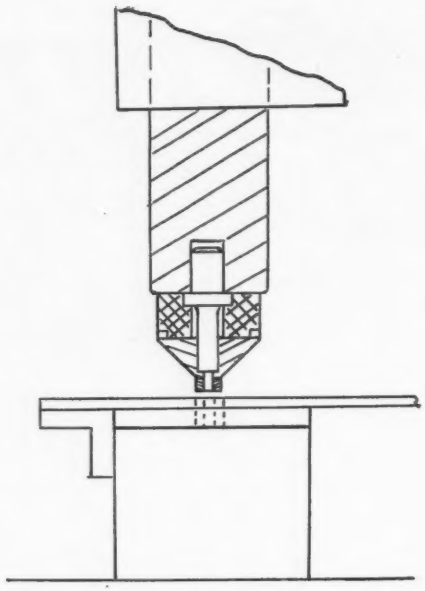


Fig. 7.

temperature of 80°C - 100°C to avoid shattering the laminated card. The punches would also have to be made larger than actual size of hole required, to compensate for varying degrees of expansion and contraction due to the variations in temperature.

For runs of work where the circuits vary, as is the case with some electronic apparatus where there are as many as 30 circuits per unit running at a rate of 10 units per week, the above method would be very costly in press tools, and some form of pantograph tool could be employed. This would consist of a power head carrying interchangeable punch and dies and a pantograph system operating over a large table where the movement of a stylus over a template passes the work under the punch. The location of the stylus in the appropriate hole in the template makes electrical contact, operating a relay which in turn operates the power press.

This method is extremely accurate and separate templates can be used for each circuit or a master template can be prepared containing all possible holes in the modulus required. The master template must be engraved with corner lines in relation to the grid holes, so that a translucent print of the required circuit can be orientated correctly over the master and secured by adhesive tape. The stylus can now be passed over and made to enter the master grid holes at the correct positions.

It is essential in all piercing operations that adequate strippers be designed to meet the peculiarities of copper clad laminate; otherwise trouble may be experienced at the soldering stage due to tracks lifting from the insulating material.

For small quantity production it is quite easy to drill the component holes by sight, but this method is not very satisfactory as the drill throws up burrs and on the return stroke the drill has a stripping action on the thin copper foil which tends to raise it from the laminated surface.

A third method which can be used for small quantities is to pierce the components in a pneumatically operated toggle press using a specially formed stripper as a guide (Fig. 7), the lower position of the stripper being turned to the diameter of the copper discs on the printed circuit card. The press is set so that the stripper face is about .187 in. away from the surface of the printed circuit card; the card is then positioned under the stripper and the hole is pierced. This method is not recommended for runs as it is very trying on the eyes and should only be used for experimental or try-out work.

final machining operations on etched cards; piercing and maintenance of correct modulus and terminal shapes to avoid cracking

Having orientated the negative with the copper clad card so that register holes are in a fixed relationship to the circuit grid, it is relatively easy to locate from register holes and to saw edges to the finished size on a circular power saw. In the case of shapes other than square or rectangular, extra holes can be drilled at the inside corners and the remainder sawn or routed to shape. It is usual to leave clear corners in negatives so that when cards are etched the corners appear in copper on the laminate, and they can be used as check guide lines to ensure that the job is proceeding satisfactorily.

Any fixing holes, or in fact all holes which are not on the 0.100 in. modulus grid, can now be drilled, using a drill jig locating from the register holes drilled in the blank card. When piercing, it is advisable to warm the laminate for holes smaller in diameter than seven-eighths thickness of card, or for holes whose diameter exceeds two-and-a-half times the thickness of the card.

In the production of piece-parts it is fundamental that dimensional accuracy is proportional to the number of operations required to finish the part, where each operation is located from the preceding machined holes or location points. It follows, therefore, that the provision of register holes at the beginning, to be used for the location of piece-parts for all subsequent operations, will produce a more accurate part. This method can be adopted successfully to produce printed circuits, but one weak link remains, that is, the positioning of register holes in the negative film. This can only be done by locating the negative on the piercing fixture by sight, using the transparent corners or special clean portions positioned to line up with previously scribed marks or cut-outs on the metal base of the piercing fixture. Unless great care is used all cards produced from the negative will be inaccurate, resulting in the component holes appearing at one side of the copper disc instead of in the centre. This is serious, as a completely successful soldered joint cannot be made if the hole is not completely surrounded by copper foil.

In order to avoid cracks appearing at the corners of square or rectangular terminal holes, it is essential

that the terminal edges be radiused and that there is an adequate radius at each corner of the terminal holes in order to clear terminal edges. If the piercing punches have no radius, then small cracks will appear at the edges of the holes, which will widen when the interference fit terminal is pressed in. In the case of terminal holes which are near each other, the presence of these cracks could cause a breakdown in the insulation of the circuit.

preventing oxidation of track prior to soldering

After etching and piercing printed circuit cards, it is necessary to remove the "resist" from the track in order to leave a clean oxide-free surface for soldering. This is done manually by scouring the track with a mixture of pumice powder, soap and water. The track is then washed in clean water and dried in a current of warm air. The components should now be assembled to the card and all soldering operations completed without delay.

There are photo-sensitive, acid-resisting substances on the market which can be left on the copper tracks during soldering operations. In order to solder successfully using this method, great care has to be taken prior to coating with this special "resist". Copper surfaces should be cleaned immediately prior to coating and they must have no trace of oxidation on the surface. Neglect in this matter will lead to unsatisfactory joints and in some cases tracks will part from the laminate due to excessive heat from soldering irons which are kept on the joints too long.

corrosion of copper track

It will be appreciated that extreme cleanliness in the work positions is necessary in order to safeguard the printed circuit card tracks during the assembly of components. Operators should be trained to handle the cards without touching the tracks with their fingers. In order to guard against corrosion in service, the tracks can be varnished after component assembly but no adjustments or changes can then be made.

separation of copper track from laminate

Pull off tests have been devised to check the adhesion of the copper foil to the plastic laminate. These tests have proved that the adhesive exerts a uniform influence over the whole area of the sheet. Nevertheless failures do occur, due to several causes. As the resin used as an adhesive is thermo-plastic, there is a danger of the track lifting from the laminate if a soldering iron is kept in position too long; hence the need for extreme cleanliness of the copper track in order that the solder will flow readily.

Large "blobs" of solder have the same effect, i.e., the concentration of too much heat at a single point, resulting in a sharp "cracking" noise, a sure sign that the track has parted company with the "laminated card".

stress on copper track due to pressure from component wires

It is important at the assembly stage to make sure that components are mounted close to and parallel with the card surface. If they are tilted at an angle (Fig. 8) there is a danger that any pressure on the component from adjacent components when circuits are mounted in close proximity could result in the track being forced off and probably fractured.

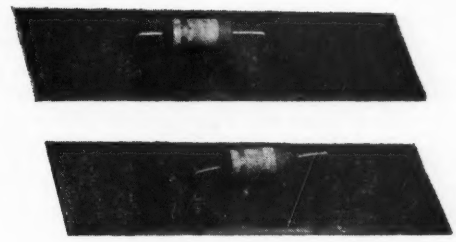


Fig. 8.

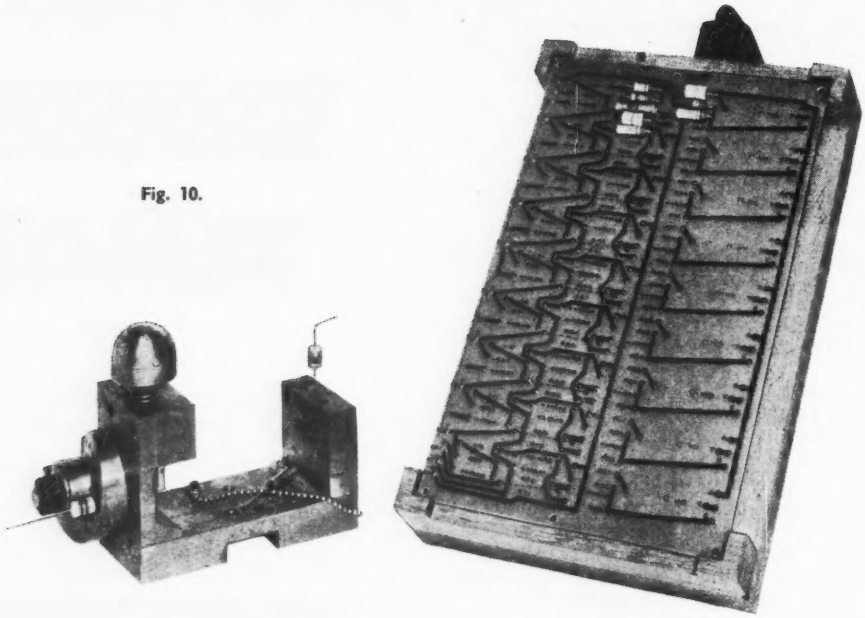
One method of making sure that component wires do not exert a pressure on the track is to make a kink in each conductor wire to form a stop (Fig. 9).

Fig. 9.

burnt laminate due to careless soldering

In conventional type wiring it is usually easy to avoid damage to surrounding components or component mounting equipment, but in printed circuit work, owing to the close proximity of the conductor to the laminate, special care must be exercised in order to avoid damage by heat. To this end it is necessary to provide special bits to suit the needs of the job. A new soldering method has also been evolved which consists of applying heat first to the component conductor wire and at the crucial moment transferring the heat to the delicate copper foil whilst feeding in solder to make the joint. In addition to the fact that burnt laminate is evidence that the correct procedure is not being followed, the damage to the laminate can lead to the absorption of moisture through the damaged part.

Fig. 10.



dry joints and excess solder at junction of component conductor wires and the copper track

Dry joints in soldering may be attributed to several causes; such as a deposition of grease on a conductor wire, a film of flux between the wire and the solder, or one of the two parts being joined not being raised to the correct temperature, resulting in the solidification of the solder before it has wetted the surface to be soldered.

Whatever the cause, the result is a faulty circuit. Visual detection of dry joints is greatly simplified if joints are neat and uniform in appearance, as the black hairline between solder and wire can be more easily seen. On printed circuit work it is therefore important to ensure that conditions are provided which are conducive to neat and uniform soldered joints. These conditions can be enumerated as follows :-

1. Scrupulously clean tracks and component wires.
2. Component holes pierced central with copper discs.
3. Soldering irons correctly maintained and correct temperature held at bit.
4. Correctly shaped bit.
5. Resin cored solder of the correct gauge for the job.
6. Component wires cropped to the correct length, as solder will build up on a wire which is protruding too far above the copper track.
7. Adequate training for operator and comfortable operating conditions, including proper iron rest and clean pad for "bit".

assembly of components to printed circuit card

The type of fixture required for assembly of the components depends on the quantities required, and for large quantity production some methods of "dip" soldering would have to be employed. Using this method, the cards would be loaded with pre-formed components from a magazine feed machine, each size of component being contained in its own magazine, the card being transfer fed under each succeeding station until the assembly was complete.

The loaded card would then pass over a fluxing spray and continue its journey across the crest of a "wave" of solder generated by a gear type pump immersed in a bath of molten solder.

After this operation, cards are examined and any missed joints are hand soldered, using a soldering iron.

In some special cases the copper tracks are silver plated or tinned as a protection, but generally speaking they are left bare, or possibly given a coat of varnish to guard against corrosion.

For short runs or small batch production, it would not be possible to tool up to this extent.

It may still prove economic to use some form of dip or fountain soldering, but automatic component insertion would not be possible, due to the numerous "set ups" between jobs or at each circuit change. For small scale production it would be sufficient to have wooden frames on which to rest cards while components were assembled by hand (Fig. 10). When all components are assembled a foam rubber sheet is placed over components, card and sheet are reversed and placed in a rectangular fixture which holds the loaded card securely with the track side up and components down, the rubber holding them in position. Wires can now be cut approximately $\frac{1}{16}$ in.

from track surface and soldering completed, using an electric soldering iron.

Component wires can be straightened prior to assembly using a simple device consisting of two wooden boards with slots machined along their length to clear the body of the component (Fig. 11). The bottom board is dusted with French chalk, the components are placed in position, the top board placed on and slid back and forth. Three or four passes are sufficient to straighten the component wires. Wires can now be formed using pliers or simple formers.

In some components which may have their characteristics changed by heat, it is necessary to provide some form of heat sink. This may take the form of a curl at each end of the component wire.

storage of copper laminate sheet

In common with ordinary synthetic resin bonded paper board, the copper clad sheets should be stored flat, preferably with a layer of paper between each sheet. The reason for this is that the sheet will warp very easily if stored in a vertical position, making subsequent operations such as fountain soldering and coating prior to etching very difficult.

Some firms prefer to purchase boards or cards already cut to the required dimensions plus the scrap border, which is removed after etching. This method of buying has some advantages which can outweigh the extra cost involved. There is less risk of warping than there would be in sheets. Any defects or blemishes on sheet material means that the whole sheet would have to be sent back to the supplier, causing delay, whereas when the order is in separate cards only the damaged cards need be returned.

It is generally accepted that synthetic resin bonded paper sheet gradually becomes brittle with age, and it has been found that material which has been in stock for more than six months is liable to crack when being pierced. It is also unfortunate that while the electrical grade of the material is kept strictly to specifications, the mechanical strength of the material varies considerably. This may be due to a variation in the curing time, or to differences in the resins used from batch to batch.

inspection of cards after etching

When the printed circuit cards have been etched and cleaned they should be carefully examined for continuity of the copper track.

This is best carried out by using some form of light box having an opal glass screen. The glass is obscured by black paper except for an aperture of the same size as the card. The card is now placed copper side up over the aperture, the surrounding room lights are put out and the box lights are switched on. Any track defects, such as scratches or breaks, can be easily detected.

conclusion

At this stage in the use of printed circuitry by the electrical engineering industry in this country, it is true to say that very few companies have laid out plant and equipment for the production of printed circuit wiring in quantity, using all the automatic and semi-automatic devices available. This may be due to the fact that printed wiring is still viewed with doubt in some quarters. It is felt that it would be safer to build up electrical equipment having conventional wiring with printed circuit sections only, which could be replaced by conventional wiring should the printed wiring prove to be a failure.

There are some grounds for doubting the reliability of this method of providing neat, clean and foolproof wiring, the chief cause of worry being that the tracks will fall off! The cure for this state of affairs is surely to establish some basic track dimensions and adhesive strength compatible with electrical requirements.

Unfortunately, the electrical requirements are often fully met in both materials and design whilst the mechanical strength of the materials and mechanical design requirements are ignored, or, at best, are given a very reluctant second thought.

Circuit engineers should be acquainted with some production engineering requirements; to quote one which is often forgotten: track termination discs should be as large as possible so that good soldered joints can be made.

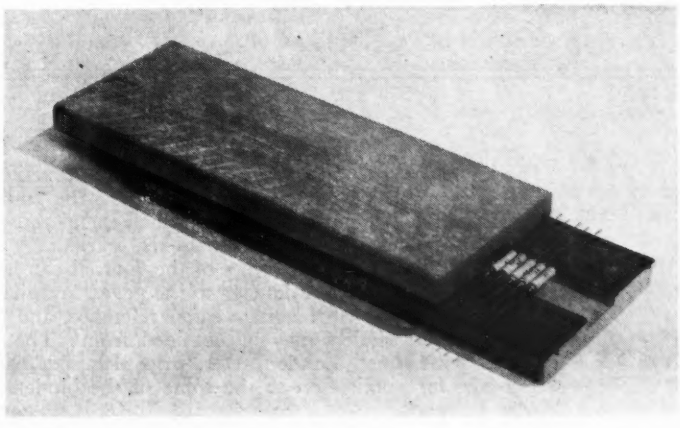


Fig. 11.

It is the practice in some firms to have photographic, chemical, machining and assembly processes carried out in separate departments, often under separate guidance. Whilst this may be suitable for development and small jobbing production, it is totally unsuited to large scale production. In order to produce economically, it would be necessary to set up production on a flow process basis having all the processes in one department under one head.

The set up would provide for automatic coating and etching of circuits, transfer to flux baths, tinning if necessary, washing, cleaning and drying ready for assembly. Component assembly would be semi-automatic, the components being magazine fed on to forming dies and then passed down to be inserted into the moving cards. Component wire would be clenched on the loaded boards and conveyor-fed over a fountain soldering machine, as previously described.

In this semi-automatic method of producing printed circuits, operators would have to be carefully trained and, contrary to the popular belief that automation will dispense with skill, it will be required in even greater measure in the future.

REFERENCE LIST

1. Fountain soldering refers to the method patented by Fry's Ltd.
2. Automatic insertion of components refers to the "Dynasert" machine manufactured by The British United Shoe Machinery Co.
3. Fig. 3 and references to the vacuum table and camera refers to the "Hunter Penrose" 16 in. wide angle lens, process camera, and the "Hunter Penrose" vacuum table.

THE POSSIBILITIES OF THERMONUCLEAR POWER AND ITS SIGNIFICANCE FOR AUSTRALIA — continued from page 170

Is this a scientist's pipe dream ? I do not think so. Even at the present time the United States is prepared to sell heavy water at £20,000 per ton, equivalent to about £50 per lb. of contained deuterium. As a source of power 1 lb. of deuterium is equivalent to about 3,000 tons of oil worth, say, £10,000 at least. Using oil fuel and proper methods of heat conservation, water can be distilled at a cost of a few shillings per thousand gallons. Thus, allowing for very great relative costs of "burning" deuterium as compared with oil, it is clear that the prospects of producing fresh water at a few pence per thousand gallons are extremely good.

Cheap industrial power without the horrors and discomforts of coal mining, the dirt of coal burning, the radioactive hazards of fission power from uranium, or the unreliability of imported oil which must disappear in a generation or two — this is what thermonuclear reactions may well provide and is one of the most attractive goals of human endeavour today. It is not production enginering in the sense that this Institution understands, but it lies at the very core of the production engineering which grew out of the discoveries of Newcomen and of James Watt, the greatest first step in the industrial revolution which created modern civilisation.

JOURNAL BINDERS

The increased size of the Journal has made impractical the present type of binder, and as a result of requests from members, the Institution is now able to supply the "Easibind" type of binder, in which metal rods and wires hold the issues in place, and which is designed to hold six Journals.

It will be found that copies of the Journal can be quickly and simply inserted into this binder, without damage to the pages, and that binding six issues at a time, instead of twelve, will facilitate easier reference, and handling of the volumes.

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management of men

by Dr. W. L. KENT, J.P.

a Paper presented to the Liverpool Section of the Institution, 12th November, 1958

THE subject on which I have been asked to speak tonight is taken, I understand, from your examination syllabus, as are all your lecture subjects for the current year. I have therefore reviewed the syllabus under this heading but I felt that you would not wish me to attempt to cover it comprehensively and much less would you wish me to describe techniques, so I have dipped into the syllabus at points where I thought my own experience might be of value. I am therefore making no attempt to work to a set pattern, but rather to deal with what I hope will prove to be interesting aspects of this subject which will lend themselves to discussion.

The whole subject of man management is, of course, one of considerable controversy at the present time. There are those, on the one hand, who assert that men with a scientific education and background are completely unsuited to the direction of others, which they claim should be left to those who have been educated in the humanities; whereas, at the other extreme, we have those who think that the scientist should be pre-eminent in all things including management. As is often the case, it is likely that the truth lies well between these two extremes and I would suggest that a man's particular brand of learning has very little to do with it, because success in the art of management depends upon qualities of personality, character, and temperament which may be possessed by people of very different kinds of education.

Naturally, I am inclined to the view expressed by the late Lord Cherwell that in these days "it is more important to know about the properties of chlorine than the improprieties of Claudius", because I think that in the modern world a manager who has been brought up on the science side—using this definition in a very broad way to include not only chemists and mathematicians but also metallurgists, engineers and others whose fundamental background has been an understanding of the basic sciences—has a considerable advantage over anyone who does not possess scientific knowledge, because he can more readily arrive at decisions connected with the technical side of the business and these must be many. In addition, as Sir Alexander Fleck has recently pointed out, the scientist has a great deal to offer in the application of scientific methods to the analysis and solution of administrative problems.

definition of manager

I propose to return again to this question of the characteristics of a successful manager, but first of all I think we must define what we mean when we talk of a "Manager" because, as a title, it can mean so much — or so little! I know of companies where there are so many managers that people in charge of quite small sections, employing only about five people, have a managerial title. On the other hand, in my own Company the only persons at our factories who have the title "Manager" are the

Manager himself and the Assistant Manager who is his deputy, and similarly the term "Manager" only appears in the titles of quite senior men at Head Office; but I also know of one or two companies where the term "Manager" is not used at all. By and large, however, for the purposes of this Paper, when I speak of a manager I shall be thinking of someone above the status of Foreman who is in charge of others, so I shall be thinking not only of the man in charge of a large factory—often called the "General Manager"—but also of all his Departmental Heads and their deputies, together with the Superintendents and Assistant Superintendents of sections of the factory. In addition, there will be many others having a responsibility for people such as Plant Engineers, people in charge of Planning, those in charge of Inspection and Warehouses and those in charge of the offices or sections of them.

a two-way responsibility

It is important, when we are thinking of those who have responsibilities of staff status *for* other people, that we remember that each one, whatever his own position in the hierarchy, is also responsible *to* others of managerial status. In the last resort this applies to everybody in an undertaking because, although we might regard the Chairman of the Board of Directors as being the highest manager in the hierarchy, we must remember that he is not really his own boss because he is responsible to the shareholders. In a successful undertaking this may not weigh very heavily upon him, but there are circumstances in which the shareholders will exert pressure upon the Chairman of the Board and, if they so wish. the shareholders can turn out the Chairman and the Board just the same as *they* can turn out those of us who are of lower status.

The point I wish to make in this connection, however, is that when we think about man management we should not just think about our responsibilities for and our relations with those we manage; we should also think to very nearly the same extent about our responsibilities to and our relations with those who are in authority over us, because we cannot be successful managers if either side of the relationship is unsatisfactory. If our attitude to those above is not as it should be, we can scarcely expect that our management of those in our charge can be on the right lines and, conversely, however good our work may be for those to whom we are responsible, it can scarcely be good enough if our relations with those we manage are unsatisfactory.

the ideal manager

Much has been written of the make-up of the ideal manager and I do not propose to deal with this subject in great detail, but there are a few points to which I think it proper to devote some attention.

In the first place, I think we can accept, as a general axiom, that the more senior a manager the lower the technical content of his job should be. The manager of a large factory will have a considerable technical staff to assist him and, apart from the fact that it is their job to advise on the technical aspects of the work, he will not really have the time to devote to it. If he has come up through the technical ranks himself, he will naturally have a ready understanding of proposals which are submitted and will be able to bring a constructive criticism to bear during discussions when decisions are about to be made on technical matters, whether they refer to new plant, new processes or to modifications of plant and processes already in existence. The major part of his time, however, will be devoted to general administration in which he will give small portions of his time to each of his departmental heads, but will leave a fair amount of time available for consideration of organisational problems, human relationships, and the future of the business and those who work in it.

administrative ability

As one goes down the scale, however, in most factories the technical content of the work of lower grades of manager will tend to increase until half of their time, or possibly more in specialist departments, will be spent on technical matters. Nevertheless, whatever the grade of manager his ultimate success will depend upon the ability shown as a leader and as an administrator rather than as a technical man. This is not surprising when we reflect that management is essentially a social responsibility which arises because people are working together and some must guide and supervise.

In effect, the primary duty of all grades of manager is to provide conditions in which all the people under their control can give of their best. This applies whether we think of a small workshop, a large factory or a modern research laboratory.

What are the fundamentals which enable a man to provide the conditions which will bring the best results?

Firstly, let us deal with the character of the individual himself. We all like to be able to look up to those who are in command and it is essential, therefore, that the manager should be a person of integrity having high moral values. Arising from these, he will possess a strong sense of justice reflected in fair play for all and a keen interest in personal problems. Another aspect of character is courage and while a reasonable physical courage may be called for on occasion, it is much more important that managers of all grades in industry should have moral courage—the more the better!

Secondly, let us think of temperament. I have heard it said that one of the most valuable possessions of a manager is a sanguine temperament, which is defined by my dictionary as meaning "inclined to hopefulness"; we should perhaps say "inclined to look on the bright side." I personally am disposed to accept this view, because generally the people who overcome difficulties are those who feel they *can* be overcome; persons who look on the dark side are often beaten before they begin. But apart from that, a factory or a workshop tends to take its tone from the person in charge and if he is reasonably

bright there will be a bright "atmosphere" about the place which will be all to the good. Naturally, this kind of thing can be overdone—our definition was *"inclined* to hopefulness" : not so frightfully optimistic that difficulties are overlooked instead of being tackled, not so bright and breezy that there is no discipline and in consequence efficiency suffers.

When one reads the newspapers nowadays one might be pardoned for thinking that the most precious possession of the man at the top is an "unflappable" temperament! Perhaps it is when he has to deal continually with emergencies of a life-and-death nature, but fortunately we do not need to do this so much in industry and I would suggest that real "unflappability" also carries with it a suggestion of superiority akin to coldness or aloofness, These should be avoided as much as the tendency to panic.

More important, I think, are qualities such as decisiveness and yet a certain measure of restlessness. The decisiveness that prevents people feeling we are so changeable that they never know where they are, and at the same time is not tinged with obstinacy or inflexibility; the restlessness that is always seeking new and better ways, but is not so restless that subordinates can never settle down to complete one thing before they are hurried on to the next.

Overall, I suppose, we need an equable temperament—one which only occasionally (and then, we hope, for good reason) sends us into extremes of behaviour or attitude. This will be apparent in most of the traits I have mentioned and is even more obvious when we think of the root of all I have just been talking about—temper! We all know that the irascible manager works under several serious handicaps, fear, dislike, and—from the majority—a lack of wholesome truth. Here above all is the need for equanimity, but please don't interpret this to mean that the good manager *never* " goes off the deep end ", because I am quite sure it is sometimes good for him and others that he should do so.

importance of leadership

And now, in all that has been said on character and temperament we have been verging upon the third point I want to deal with in this section of my lecture, namely, leadership. A leader "shows the way by going first" but he also "guides", "directs", *and "induces"*. It is this inducing which we have been having at the back of our minds because it is so much tied up with personal qualities of character, temperament, and all we integrate into the one word personality, but we must not neglect the other aspects of leadership, because they are so important.

What about this capacity for "showing the way" —how does that come into our daily jobs? It isn't always easy to see that as a separate issue and in consequence there is a tendency to belittle it. Suppose we start by thinking of the unpopular decision that has just come "from upstairs". How do we tackle that? By telling our subordinates about it in an apologetic way and saying just what we thought about it when we first heard of it—or by thinking about it first, finding out everything in its favour and then putting it over as something over which we are prepared "to show the way by going first"?

And then, of course, there are endless problems coming "up" the line with which we have to deal. If we know our jobs it is simple to deal with many of them, but it is when the real troubles come that leadership becomes more difficult—the need to show the way by finding better solutions than those already available, the self-confidence to put them forward, the ability to stand up for these and to get them accepted, the courage and resolution to go first in putting them into practice and ensuring that the policy laid down is in fact implemented—all these are essential ingredients of leadership. People will follow a man who possesses these qualities and if you doubt it just think of Winston Churchill and Montgomery, and other successful war leaders, and you will see that it is true. That is not to say that industry should be handled like a war, or that the qualities which make a war leader will be equally successful in industry; but by and large there are characteristics of leadership common to both and among them those that I have mentioned.

However, it is not my purpose to enumerate all the qualities required in a manager. I have pointed to some of the most important because we could not discuss man-management without a background of this kind, and I conclude this section by hoping that I have said sufficient to provide that and to stimulate thought.

I am now going to deal with a few essentials to good management which I think need special emphasis.

★ ★

Dr. Kent graduated in metallurgy at Birmingham University and was awarded his Ph.D. for post-graduate research. His industrial experience covers a period of 30 *years, all with The British Aluminium Co. Ltd., at Bank Quay, Warrington, where he has been Manager for* 10 *years.*

Keenly interested in the problems of management and the training of all grades, Dr. Kent is a member of several professional bodies and a Governor of Warrington Technical College. He helped to found the Warrington and District Productivity Committee, being one of its early Chairmen. He is a Past President of the Warrington Chamber of Commerce, Past Chairman of the Lancashire Chambers of Commerce Committee, and a Justice of the Peace for the County Borough of Warrington.

co-ordination

All writers on management rightly stress the importance of co-ordination. Every successful manager has the capacity to bring people together to work effectively as a team. Obviously the first requirement of anyone desiring to obtain co-operation from others is that they should be co-operative themselves, and I think the second is that they see and state clearly what the objectives of their co-operation are. A prerequisite, however, is that "sticky" problems should be dealt with early and on this I cannot do better than quote Urwick (*The Manager*, February, 1957, page 115) :—

"the best kind of co-ordination consists not in knocking heads together after friction has occurred between individuals, but in anticipating possible causes of dispute and ironing them out before trouble can develop. Good managers are not trouble-shooters after the event. They are abortionists who stop embryonic troubles from getting born. This is a continuous process in any organisation."

Urwick goes on to underline that it is the job of individuals—and not committees—to take this kind of forestalling action, though of course one of the stages in doing it effectively may be the act of bringing people together to get all the facts to decide what shall be done.

communications

This question is allied to that of communications. I will not spend much time on it here in view of its popularity as a subject for conferences and management literature, but it is most important and you can only neglect it at your peril. It is perhaps commonplace to say that if management of people is to be satisfactory a first essential is effective communication, but I know from experience that a large percentage of managers who are ready to concede that point do nothing to make themselves efficient in it. The first needs, surely, are that one has a good command of the English language and is fluent in the use of both the written and the spoken word; a corollary is that these abilities should be reflected in the use of simple words and an easy style that assist understanding. These things are only acquired by hard work and conscious effort but are well worth the trouble, and to the young man who aspires to be a good manager I would say that an essential part of his training is to take part in discussions at meetings like the present and, if possible, to join a debating society. All my adult life I have been thankful that some inner urge prompted me to join the School Debating Society and to take a leading part in one debate every year, with impromptus whenever possible, however much my knees shook and my tongue dried up in my throat. These things still happened when I first met a sit-down strike and on many occasions when I had hurdles to overcome in meetings with senior officials or with employee representatives, but owing to the fact that I had experienced it all before, I was not seriously handicapped.

There are some who do not experience these terrors, whose confidence is so great they can take on anybody any time, but both for them and all the rest another essential to good communications is preparation. Very often the man who dare not stand up to say what he thinks has handicapped himself from the start because he did not prepare himself beforehand, and incidentally this is also one of the reasons why committees fall into dispute. The manager who calls a committee to consider a problem should prepare himself in good time and should expect that those attending come prepared also. This avoids loss of time, enables all the facts to be gathered together quickly and in good order, and so lays the foundations for prompt and wise decisions.

participation

These considerations lead naturally to the point that whenever possible the wise manager gives his subordinates a sense of participation in decisions which are made. This will naturally take place in individual discussion so far as departmental matters are concerned, but in dealing with problems of a general nature which may affect most of the people in the factory, a great deal of it will be done through committee work. There is, of course, a certain limitation of the extent to which participation can take place, because obviously if a decision has been made at a higher level it may be merely a matter of promulgating the decision and gaining acceptance for it; on the other hand, it may be necessary to work out the implementation of a decision made at high level and in such an instance the maximum amount of participation should be given in that stage. Perhaps these techniques of co-ordination, communication and participation can be illustrated by an example taken from my own experience.

example of co-ordination, communication and participation

The example I wish to quote is fairly recent and concerns the conditions applying to the 1957 wage increase. My Company is not a member of the Employers' Federation and wage rates are negotiated separately, but we do tend to follow national agreements made by the Employers' Federation. In consequence, when agreeing the wage increase for 1957 we obtained an assurance from the unions of their willingness to co-operate with the Company in trying to secure improved productivity and better discipline.

We decided to follow up on this and as a first stage two or three meetings were held with Departmental Heads. The first meeting, at which I announced the objective and indicated my ideas of the kind of things we could tackle, was comparatively short. Other contributions were made to the list and we then adjourned for a few days to give everyone an opportunity of thinking things over. When we met again we discussed all the suggestions made, decided upon those which should be followed up and reviewed in some detail the methods of implementation; shortly afterwards a further meeting

was held in order to reach final decisions. Following upon this preparatory work, in which you will note that all Departmental Heads participated, we called a meeting which was attended by all staff above the rank of Foreman who have control over other people. In addition, a few specialists who have considerable contact with employees on the floor were also invited, despite the fact that they did not possess line authority, in order that they would be aware of our programme and could talk intelligently about it if the need arose.

At this meeting the whole programme was put before them and questions and comments invited. Following that there was a special meeting for all Staff Foremen in order that they could be completely briefed. The day after the meeting of Staff Foremen we had meetings with all the Shop Stewards, to whom the programme was again submitted and opportunities given for questions and comments.

allaying apprehension

As usual on these occasions, the main necessity was to meet objections and to deal with fears arising from too vivid a use of the imagination. Notes were made of a number of points of detail which required attention and these were dealt with later that same day through the appropriate staff. The aim was to remove every obstacle, however small, to the carrying through of the full programme, which covered general timekeeping, not only in relation to the time of attendance at the beginning of a shift, but also leaving work early for meal breaks, the question of the length of tea breaks and action against employees responsible for unsatisfactory work or for unreasonable absences from the job. We also improved the system of warning people for infringements, in order that we should be in a satisfactory position if disciplinary action had to be taken.

It may be said that in all this there was perhaps nothing very new, but there was to be a general tightening up and for this purpose it was essential that we should have the full support of every member of the supervisory team from the Chargehand upwards, and also the support of the Shop Stewards. The final stage consisted of talks to the Chargehands and Assistant Foremen on every shift, and at each of these talks we arranged for staff who had been absent on holiday or sick leave in the previous talks to be present, so that they would know what was going on. We also added a sprinkling of others upon whom the main responsibilities would fall, so that the shift supervision would see that they were getting the full support of the staff apart from myself.

We decided to have a starting date for this campaign against lost time and so forth, and a factory notice was posted ten days beforehand informing employees of our intentions and asking for their co-operation. On the day that the programme commenced, every Assistant Foreman and Chargehand coming on duty received a personally addressed confidential envelope containing a letter from me reminding them that the campaign started that date, enclosing a copy of the notice, which of course they would already have seen, and indicating that I expected them to tackle any problem which arose with firmness but also with discretion. Naturally, every Foreman coming in at 7.30 also received a letter and this contained a copy of the letter sent to his subordinates and similarly, at 9 o'clock, on coming into work, every Departmental Head and Superintendent received a letter which contained copies of the letters to the Foremen and the Assistant Foremen and Chargehands. Each of the letters was appropriate to the grade receiving it and each of them was signed individually by myself, although of course the letters themselves were produced from stencils. In all, these preparations and the follow-up took something approaching five days of my own time and in total perhaps up to a day of the Departmental Heads' time, but I have little doubt that the success of the campaign was due to the careful preparations made, involving full prior consultation with the employees' representatives and the very complete communication of every aspect of the matter to all concerned in it, and also the follow-up letters which put all grades of supervision on their toes from the time of starting.

Incidentally, there is one point about putting over matters of this kind to various groups of supervisors which I consider to be very important, namely, the use of a prepared and written out speech. I have found from experience that it is not easy, even on a comparatively simple matter, to put over the same speech several times—even three times—without subtle changes of emphasis unless full notes are used. It is vitally important that senior staff and their assistants and the foremen should all have the same main instructions and the same supporting story without different shades of meaning, and also that the supervisory grades on each of the three shifts should have the same too.

So I always use a typed script and I am quite sure the audience do not think any the less of the speaker for doing it. They are set a good example of careful preparation and as a minor aspect it also warns them they have no hope whatever of getting away with personal aberrations from the declared policy.

Also, in putting these things over and answering questions I always have the assistance of my deputy —or, in his absence, a senior Departmental Head— to ensure that I do not go wrong or give a false impression. I find also it is most helpful if the session is a long one, because the second party sometimes sees a point behind a question that might be missed by the main participant, and often they can come in to reinforce a point most usefully.

Just a final point on this subject. We also had a similar campaign with respect to staff and for this purpose I addressed a meeting of all staff employed anywhere about the offices or factory to indicate what we required from them too.

decision-making

There are some who feel that the making of good managers, particularly in the higher grades, is centred upon the techniques of decision-making; they think that if we could determine the underlying principles

of decision-making an important gap in the training of managers could be filled. A good deal has been said and written upon this subject, and Professor Shackle of Liverpool University has produced a mathematical diagram expressing the relationship between the uncertainty in making business decisions and success or failure. This has given rise to considerable discussion in learned quarters—although whether these investigations will have a practical outcome is difficult to say at the present time— but it seems to me that we cannot talk usefully about the position of decision-making in management affairs unless we clearly distinguish between the different kinds of decisions that have to be made. I think that an easy way of classifying them is on a time basis, and if we do this I think it will be recognised that different techniques may be required for dealing with different kinds of decisions. My definition would be as follows :—

(1) short-term decisions

These are decisions which have to be given more or less on the spot and they can conveniently be divided into two categories :

(a) *Matters upon which a decision should be easy because the person having to make it possesses an adequate knowledge of the background, which enables an immediate decision to be given.* Such decisions continually arise during the day for all grades of manager, not only on the technical plant where job knowledge, customer's requirements and so on are of primary importance, but also in the management and control of people where knowledge of the Company's personnel policy, factory rules and so on are the background information which the decision-maker must have at his fingertips. By and large these decisions present no real difficulty to the person who is on top of his job. They are made readily and with confidence.

(b) *Decisions which it is necessary to make because of an emergency.* Such decisions are those which we generally characterise as having to be made "on the spur of the moment". They call for rapid thinking and the correctness of the decision made is determined by a large number of factors, including the knowledge and experience of the decision-maker as well as his character, intelligence and good fortune.

I suppose it is here that the advantages of a reasonable amount of "unflappability" are most apparent. It is essential to keep cool to allow the brain to do its best work, and the first thing to decide is whether there is in fact an emergency or not. Some people are so nervous and panicky that they live in a continual state of emergency and so tend to make hasty decisions on matters which do not require them.

Assuming, however, that we are faced with a real emergency, the main essential is to work with only such degree of haste as is called for. Obviously an outbreak of fire or an electrical mishap may call for instant action—almost without thought—and the correct degree of promptitude is probably obtained by keeping up-to-date one's knowledge of what to do and how to do it, coupled with occasional admonishments to one's reflexes on how to act if it does happen.

If the emergency is one relating to people, the need for coolness is perhaps even greater and the main need is to remove the incident from the "emergency" category to one which can be dealt with in a more leisurely way. Time does not permit us to go into the techniques which may be used here, but I think they will be well-known and all I need say is that we should make sure to be decisive and act quickly if the need for it exists; sometimes speedy action, which is not quite the best, on a careful analysis is more valuable and brings better results than a more correct action carried out later.

(2) medium term decisions

In this category we can put all decisions where the time factor allows us to investigate a situation further before making a decision; into it fall many of the decisions we have to give in relation to people and plant. Most of our production planning falls into this category and so do many of the decisions we have to make arising from requests from employees which do not readily fall into the normal pattern. In this connection, and particularly where we are dealing with people, perhaps one of the most important things to decide is whether a problem really falls into the first classification and demands an immediate decision or whether the circumstances are such that time is available—or by some ingenuity can be made available—in order to permit of further thought and particularly of obtaining further information which will enable a more accurate decision to be made.

(3) long term decisions

Into this group we put many of the matters which are finally decided by higher management, such as the purchase of new plant, the introduction of a new line of business, the alteration or rates of pay and conditions of service, either for workpeople or for staff. In these matters it is often necessary to conduct a fair amount of investigation and enquiry in order to obtain the whole of the information required to come to a satisfactory decision. Perhaps an important point here is to make sure that matters, and particularly those which affect the welfare of people, are not put into this category if they can be dealt with in one of the earlier categories, because often a problem is made more intractable and more difficult of solution if a decision is postponed unduly. However, it is really this group of decisions which people generally have in mind when they talk about the techniques of decision-making by managers, and the point they are concerned with is what goes into

making the final decision, particularly where the facts available are insufficient to enable one to proceed with certainty and the decision is based on little more than a personal opinion. This applies to many commercial matters and to those concerned with technical development where it is possible to make or lose considerable sums of money, depending upon the ultimate correctness of the decision reached.

taking action

Another aspect of this matter of the making of decisions is that when a decision has been reached, it is also necessary to put it into effect, and there are some people whose minds invariably lead them to the correct decision but who nevertheless lack the confidence to give effect to it. They find all kinds of excuses to defer action, particularly if it is one which they think will not be popular, and especially if it means unpleasantness with other people.

This leads us to a consideration of the manner in which decisions should be carried out. Obviously, the timing of a decision can be all-important and also the method in which it is handled. There are far too many people who think that a decision having been made, it is only necessary to issue a notice or a memorandum and all will be well, whereas very often a great deal of good staffwork is necessary to ensure that the decision is accepted and properly worked and applied by all concerned. In large establishments this is particularly necessary in all that affects people, because considerable dissatisfactions are bound to arise if a decision made at high level is interpreted or applied differently by managers in different sections of the undertaking. We must bear in mind, too, that while some decisions should be implemented without delay, there are others where it pays to take some time in preparing the ground before practical consequences ensue.

It is probably in this group of actions that the need arises most for correct attitudes and relationships between all grades of staff. I referred earlier to the need for us to think in terms of our attitudes both upwards and downwards, and suggested that these must be well-balanced and correct in both directions. As subordinates we have a duty to support and sustain our superiors—as managers we have a right to expect it from our subordinates, but only insofar as we ourselves give it.

Circumstances may well arise in which we have to implement decisions we do not like, and we can perhaps turn to a situation which was written up some time ago in the Press for examples which reflect many of the points on which I have been speaking.

According to this Press report, an industrial company had an agreement with certain Trades Unions providing, among other things, extensive privileges for Shop Stewards. These included facilities for paid weekly meetings; for overtime to be worked only with their permission; and for complaints from workmen to be referred to the Shop Stewards and not to Foremen.

We can well imagine the difficulties to which this agreement gave rise. In particular, the setting up of the Shop Stewards as a competing group of supervisors broke all the principles of good management and especially that the line of authority from the management to the grade of supervision nearest the ordinary grades of worker should be unbroken. Many grades of staff must have felt that this decision was wrong at the time it was taken, and one can well understand any resentment which Foremen might have felt on being supplanted by the Shop Stewards insofar as dealing with complaints from their men were concerned. Nevertheless, the decision having been made by the Company, it was right and proper that all grades of staff should implement it faithfully and do their utmost to make the policy a success, whatever their personal feelings might be.

A year or two ago there was a several weeks' stoppage of an important group of workers in consequence of which the management withdrew the agreement, and applied for membership of the Engineering and Allied Employers National Federation, which does not recognise Shop Stewards Committees or Convenors and gives Shop Stewards themselves only such facilities as are reasonably required to perform their normal Trade Union functions. This sudden and complete reversal of policy again brought its problems, but it may well be that the Company considers it was worthwhile, as relations appear to have been better since. Nevertheless, I am sure you will agree with me in thinking that such violent swings in policy are not good for the morale of any undertaking because they involve such considerable reversals in loyalty, particularly for the Foremen, that even with very good preparation and staff work it cannot be easy to secure satisfactory results.

lack of joint consultation

Apart from this, however, the policies followed seem to suggest a lack of joint consultation and of the methods which should be employed in its application; in fact, it can scarcely be said that joint consultation can be present in an organisation where the Shop Stewards are first of all elevated into the position of a particular and special kind of supervisory grade, and then later lose this position and also the privileges which had been peculiar to their own appointments. Surely the intermediate position, which is much more common in British industry, where the Shop Stewards are recognised as the duly appointed representatives of the employees and negotiate on their behalf in accordance with agreed procedures while receiving no other special privileges, is much to be preferred.

We may use this story also to point another moral —that it is no use worrying about things it is not in our power to change. By all means look forward, think constructively and—when opportunity allows—speak constructively on such issues, but until a more opportune time accept the situation without getting worked up about it. There is an American saying which has its application here:— "IF IT'S BAD FOR YOUR STOMACH ULCERS IT'S BAD FOR YOUR MANAGEMENT." Even more constructive in some ways is the European: "GOD

GRANT US THE SERENITY TO ACCEPT THE THINGS WE CANNOT CHANGE; THE COURAGE TO CHANGE THE THINGS WE CAN; AND THE WISDOM TO KNOW THE DIFFERENCE."

putting new ideas into practice

And now, finally, let us look very briefly at one of British management's besetting sins—the slowness with which new ideas are taken up and put into practice. Some will say that this is a technical problem, but in my opinion it is partly a question of the outlook of the individual and partly a matter of man-management: on both counts, therefore, it qualifies for consideration tonight.

Perhaps I ought to commence by saying that in this direction I make no claim for being different from my fellows. I am very conscious of having opposed new developments in the past, both technical and sociological, which I should not have done, and I am conscious of the fact that since I became manager of a large factory I have not always succeeded in persuading others, my Company in some things and my staff in others, to the rapid acceptance of moves which I have felt to be correct and which later have been proved to be so. I know I am not alone in this, and that it is a common trait in British industry. It is an essential aspect of good management to deal with this and in my view too little attention is given to it in all grades. How can we make ourselves and others more receptive to new ideas—so receptive that everybody is willing to push them for all they are worth and get them applied quickly?

So far as we ourselves are concerned, there is much we can do to develop a new attitude. A realisation of the existence of the problem is a good start. The next thing is the development of a really judicial attitude to new ideas so that we completely divest ourselves of prejudice and look at new proposals without bias, or, if there is to be bias, let us err on the side of being ready to give things a trial.

Perhaps here I ought to pause for a moment and interpose that all this really is necessary. In case you doubt it, may I ask *you* to think quickly of two or three people in your own place of work whose stock reply to a proposal for some new development is that it is impossible. Yes, of course, you can think of them easily! Now, have *you never* said that? Or, if you've only said it a few times, is it absolutely certain that it was impossible in every case?

There will naturally be some things that are impossible—customers sometimes try to insist we defeat the laws of nature, for example. But very many things said to be impossible in the 1930's are an accomplished fact today—and how much better off our industry would have been then and today if people had been more ready to get on with them instead of saying "Impossible!"

Now, how about the other side of it—how do we gain acceptance for our ideas, both above and below? First of all we must work them out clearly, because if we can't expound them so that other people can easily understand them, we cannot expect them to be accepted. One of the best ways of doing this is to set them out on paper, listing the advantages and disadvantages, and perhaps finally producing a report which—if it has to go to higher authority—should show if at all possible an estimate of costs and anticipated savings or profits as may be appropriate; and in this connection my experience has shown that many more matters in industry can be expressed in financial estimates than people think. (This is another of the directions in which "impossible" is often shown to be wrong).

On the other side of the picture, what are the salient features when trying to get something new accepted and carried out in reasonable time? Assuming your ideas are clear and you can make a good case, what else is necessary? In the first place, as I said earlier in a similar matter, try to give others a sense of participation by asking for their comments and suggestions, and giving them careful consideration to accept whatever you can. The attitude that "this is my idea and mine alone" will not bring co-operation; the acceptance of useful suggestions in connection with it will. And here let us remember that to bring someone else along with us it may well be worth while to accept their preferences on detail where it does not very much matter which is right. In fact, the man who is nearer to the job is often more likely to be right on such details than the General Manager.

Having said all this, it is also necessary to add that in some cases human behaviour results in these various steps being used as vantage points by obstructionists and we must watch for this. A certain amount of patience can be justified at first, but if advantage is being taken of it, then a line of action should be laid down and instructions issued for it to be given effect without further ado.

conclusion

In the limit, I suppose we can sum up our ability —or otherwise—to get things done in the way we think they should be done, and at the desired speed, in the one word "leadership". I have made some reference to it previously and it could well be the subject of more than one lecture itself, so I will content myself by referring to one of the greatest leaders of all time—Nelson. We are told that "the essence of his leadership was that he could inspire those around him to excel even their former best." One of his officers wrote "He is the cleverest and quickest man, and the most zealous in the world. In the short time we were at Sheerness, he regulated and gave orders for thirty ships under his command, made everyone pleased, filled them with emulation, and set them all on the *qui vive* . . ."

You will notice from these extracts that he knew his job, was an efficient organiser, and extremely zealous; in addition he "made everyone pleased and filled them with emulation". And so we return to the point from which we started—that much of success in management derives from the character of the man, and I think it right to add that many of the right characteristics can be acquired by the man who is willing to make the effort.

an analysis of materials and plant in current use in the furniture industry

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UP to the early years of the 19th century, the manufacture of furniture was carried out by local craftsmen working in small workshops with little or no equipment other than a kit of hand tools.

The tremendous increase in population which took place last century brought about an increased demand for furniture far in excess of the capacity of the small workshop craftsmen. Factories consequently mushroomed into being to form the embryo of the furniture industry of today.

There are today more than 2,000 furniture factories in the country, but there are now strong indications that this total represents a greater manufacturing potential than is capable of being sold. A steadily increasing number of small manufacturers are finding it extremely difficult to remain solvent, and, indeed, there is a proportionately steady increase in the numbers of manufacturers going into liquidation. The primary reasons for these conditions are :—

(i) The Chancellor of the Exchequer has imposed severe restrictions on Hire Purchase which, for the last 40 years, has been the main outlet for furniture sales.

(ii) The growth of monopolies in the retail furniture trade makes it extremely difficult for the smaller companies to trade on reasonable profit margins.

(iii) The development of high output multi-operation machinery presents a further acute problem for the small manufacturer, not only because of the comparatively high capital cost involved but also because such machinery will be capable of producing far more furniture than he can hope to sell and will subsequently require far more productive space than he has available.

Thus it is inevitable that the industry must go through a period of adjustment before consolidation can be effected, with the smaller companies being primarily affected and the larger companies — particularly those with direct interests in the retail monopolies — strengthening their hold on the country's markets.

development of machine tools, materials, and methods

The machine tool section of the industry has made quite remarkable strides in the past 50 years, and has produced a range of machinery which today can manufacture a batch of piece parts in a fraction of the time taken by the forerunners of the late nineteenth century. The principal machines of the trade are described in more detail in the section dealing with Plant and Equipment, but it is worthy of note that the machine tool makers have not only endeavoured to operate at high feed rates, e.g. at 120 feet per minute, but have equally endeavoured to develop machines which will perform a series of operations in one combined operation. In each case they have succeeded brilliantly, but it is to be regretted that the users of these machines do not always operate the machines to the best advantage. The most offending factor in this respect is the usage, sharpening, and setting of cutters. Only a minority of

furniture factories have operative toolrooms and in all too many cases the shaping, sharpening, and setting of cutters is carried out by hit-and-miss methods with little more equipment than a grinding wheel, a rule, and a square. Further, the use of tipped cutters is a rarity, the predominating medium being high speed steel. Thus, having shown excellent development in the design of high output machinery, it is now incumbent upon the machine tool manufacturers to educate the users fully into a thorough appreciation of the advantages to be gained by the use of better quality cutting mediums, and by the provision of accurate tool sharpening and tool setting equipment.

The basic manufacturing materials in furniture have always been timber and timber products, e.g., plywood and veneers. The same combination still holds today, but it is not improbable that the monopoly of these materials will undergo some reversion during the next two decades.

The development of plastics must inevitably become one of the main factors in the reversion, since the tremendously varied range and properties of such materials must ultimately show economic and other advantages over timber or plywood. Indeed, the melamine type of plastic, such as Formica, has already established a firm hold on the kitchen furniture market; and it can be anticipated that extruded plastics may oust, in some measure, the use of solid timber sections in the carcase construction of sideboards, wardrobes and dressing chests.

During the past 50 years the methods used in the industry have been revolutionised in the machining and in the polishing of the finished product, through the introduction and development of mechanical aids. The methods used in assembly have not undergone the same radical change, however, and the same basic operations still obtain, although there has been a very considerable reduction in the time-cycle taken on most operations through the introduction of quick setting adhesives, the use of pneumatic equipment in jigs and fixtures, and the greater precision and better quality of machined piece parts.

design in relation to production economy

Although there are, at any time, a myriad different designs of furniture to be seen, the same basic methods of construction will be seen in almost every piece. For example, the joints of the main carcase will almost invariably be morticed and tenoned, the drawers will be dovetailed, and the panels will be set in grooves or in rebates. In this respect, design has shown little advancement since the days of Chippendale or Sheraton, and the adherence to these methods of construction has become very deep-seated indeed.

As indicated in the preceding paragraph, the assembly methods have not improved in the same degree as either machining or polishing, and this factor is entirely due to this adherence to traditional construction in design. There can be no doubt that a more virile and more imaginative approach to the overall subject of construction would inevitably yield results which would be of the utmost value — particularly to the small manufacturer — in that reduced assembly costs would lead to a reduced selling price which, in turn, would help to overcome the sales resistance created by high deposit payments on Hire Purchase selling.

material economy

The material content of the average piece of furniture averages about 60% of the selling price. All furniture manufacturers are, therefore, very conscious of the need to minimise wastage in conversion and machining. However, despite this consciousness, it cannot be claimed that every possible means is explored to limit wastage to the minimum.

For example, in the section dealing with Materials it will be seen that a very large proportion of the timber used in this country is bought by the manufacturers as sawn logboards, i.e., with the wane and heartwood included in the boards. Both the wane and the heartwood are useless for furniture manufacture, and both finish up on the waste pile. The only use to which such offcuts, sawdust and chippings are put, is to feed them into the factory heating system. When it is considered that wastage such as this occurs in greater or lesser proportion every day in every factory in the country, it does appear that a golden opportunity presents itself to a mechanical engineer to design a compact, inexpensive piece of plant which can convert this waste timber into a usable product such as chip board, i.e., wood chips mixed with a bonding medium and pressed into sheets of $\frac{1}{2}$ in. or 1 in. thickness. The principle of wood reduction, mixing, and pressing is already established in factories especially designed for the mass production of such materials. The plant used in these instances is, of course, purpose-built and is both very large and very expensive, and results in such products as Weyroc and Bartrev. If a compact plant, such as that envisaged, were designed and made available, it would thus provide even the small manufacturer with a functional outlet for every scrap of waste and would thus again lead ultimately to reduced operating costs and to reduced selling prices, with a consequent improved selling potential.

plant economy

Previous paragraphs have indicated the strides which the machine tool manufacturers have made in developing machines which combine in one operation the function of several smaller individual machines.

In the largest, most up-to-date factories, such machinery is operated on relatively high efficiency levels. Loss of running time through re-setting, for example, is at a minimum because of the production volume inherent in such factories which, in turn, permits the machining of large batch quantities of piece parts.

The same favourable circumstances do not apply to the other sections of the industry since the smaller the factory, the more restricted the batch quantity must be, with a proportionate increase in the amount of re-setting time required. This loss of machine time in the average factory affects the furniture industry to a much more appreciable degree than in, for example, the normal medium engineering factory, since the time cycle per piece part operation is so very much smaller. This can perhaps best be illustrated by the fact that the complete machining time for the average piece part amounts to not more than two minutes and will include, on average, not less than six operations.

The basic problem of setting time cannot, of course, be entirely eliminated, but it could certainly be reduced by a more determined effort on the part of the designer to create standard piece parts for frames and drawers, for example, and ring the changes in design around a standard construction. In this way more operations would be standardised, greater batch quantities would be made possible, and loss of machine running time would be proportionately reduced. Again, a better appreciation by the manufacturer of the advantages of better cutting tools and sharpening equipment would prolong the life of the tool and subsequently reduce the time lost by resharpening.

materials

basic types in common use

Timber species are broadly divided into two categories, hardwoods and softwoods. Hardwoods are those trees which are deciduous and which are bare of leaves in Winter. Softwood is the name commonly applied to those cone-bearing coniferous trees which retain some form of leaf throughout the whole year.

The description is one which is generally accepted but which, in actual fact, is not entirely accurate, since the hardest and heaviest softwoods are heavier than the softest and lightest hardwoods.

In general terms, however, in the range of timbers in common use in this country, the types of softwoods used are most certainly softer and more liable to bruising and wear than the traditional hardwoods such as oak, beech and walnut. Thus, the furniture industry with few minor exceptions uses hardwoods throughout in the manufacture of its products.

hardwood species and sources

The traditional types of hardwood such as oak, beech, walnut and elm, formed the backbone of furniture materials for many, many years prior to the Second World War. Between the two World Wars the more popular, cheaper ranges of furniture were largely produced from American oak, which was imported into this country in vast quantities and at a considerable price advantage when related to the price and quality of homegrown oak. The economic situation of the country after 1945 prevented large scale importation of timber from dollar countries, and the timber trade had to search elsewhere for suitable hardwoods. The situation in the other European countries at that time was such that large quantities of timber were not readily available for export, nor was their basic price wholly attractive to the British market.

Attention was therefore directed towards the vast tracts of forest in Nigeria and the Gold Coast, and hitherto little known species of African hardwoods began to be consumed by the furniture industry in steadily increasing quantities. The most popular types which were developed from that situation are abura, limba, agba and idigbo, and it is likely that these species will continue to be largely used for many years to come, principally because of their economic advantage over timber from other sources.

From an aesthetic point of view it is perhaps regrettable that the use of these substitute hardwoods has become so commonplace and so accepted as part of the material structure of the industry, for no matter how cleverly such timbers are stained and polished they can never equal the natural beauty of a piece of fine-grained oak, walnut or beech. Several reputable manufacturers still endeavour to give the buying public pieces of furniture which contain a proportion of solid oak but these are relatively few and, in any case, it is virtually certain that the solid oak is only utilised on the outside faces of the piece of furniture and that one of these substitute hardwoods is used for every interior member.

conversion

These African timbers are shipped to the U.K. either as logs or as sawn square edged boards. The proportion of logs imported is, however, alarmingly high and provides a factor which could well stand further consideration by both importer and manufacturer.

The logs are, of course, cylindrical in section and, as such, are wasteful of shipping space. Sawn, square-edged boards can be stowed with a much more efficient space factor. Further, up to 20% of the average log is lost as waste in the sawing and conversion of each log. This can perhaps be best illustrated by Fig. 1, which shows a log converted by straight sawing into square edged boards.

Each saw cut removes between $\frac{1}{8}$ in. and $\frac{3}{16}$ in. of timber as sawdust. The black areas around the

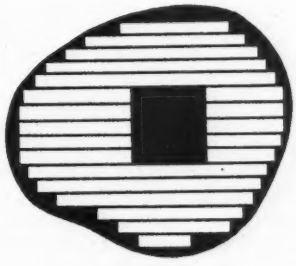

Fig. 1.

Fig. 2.

periphery represent the bark or wane areas which are useless for furniture production, and the black square shows the area of heartwood which, again, because of its spongy texture, is also unsuitable for furniture.

Further wastage occurs when each board is machined into the different sections required for the finished product. Fig. 2 shows the conversion of such a board into typical section.

If square edged boards of a suitable nominal size, e.g., 3 in. × 1 in., were used, the machining waste involved is markedly reduced. Additionally, the use of this type of timber permits savings in labour costs since the size of board eliminates rip-sawing to width and, in this form, allows much greater efficiency in handling.

conditioning

One of the main constituents of a living tree is water. The water is contained in the myriad cells which lie axially along the tree trunk and the weight of moisture in relation to the overall weight of the tree can be as much as 50%.

After felling it is therefore necessary to allow a period of several weeks to elapse before sawing since, as soon as the trunk is severed from its roots, the cells begin to lose their moisture and they shrink in minute proportion. If the log is sawn into boards immediately after sawing, the moisture loss and subsequent shrinkage is accelerated, thus causing excessive splitting and distortion of the sawn boards.

The resultant moisture content is still too high for furniture manufacture, and must be reduced further to a moisture content approximating to that of atmosphere to prevent shrinkage and distortion of the finished product. It will be readily seen that a piece of furniture such as a wardrobe would be drastically affected by such conditions, since the framework or carcase is composed of solid timber members firmly secured to each other by, usually, mortice and tenon joints. Shrinkage in any or all of these members will most certainly cause serious distortion, and may even result in the breakage of a joint or in the splitting of a member should the shrinkage action set up a torsional stress.

The reduction of moisture in the sawn boards to the required moisture content can be achieved by both natural and artificial means. The natural, traditional, method is to stock the sawn boards in such a manner as to permit the maximum circulation of air around each board, as illustrated in Fig. 3.

This method, known as air drying, is not wholly suitable for present day needs, particularly in the larger types of factory where mass production methods are applied, the principal deterrents being time and storage space. On average, a period of 12 months is required on 1 in. timber to reduce the moisture content to that approximating to outdoor atmosphere. It is then necessary to stack the timber inside the factory for a period of between approximately three to six weeks to reduce still further the moisture content to that of the atmosphere of a normal house or office. Thus, those manufacturers who utilise air dried stocks must contend with the following disadvantages :—

(a) an excessive capital outlay since stocks must be carried over a period of several months :

(b) excessive storage costs since storage yards must be proportionately greater in size :

(c) loss of productive space since stocks must be retained in the factory for between approximately three and six weeks.

The artificial method of seasoning or drying timber is known as kiln drying. The kilns are specially constructed brick structures with equipment to control both heat and humidity within the chambers. In operation, the timber is stacked on a movable trolley in much the same way as the stacks are prepared for air drying. The trolley is moved into the chamber and the doors are closed to seal off the contents from normal atmospheric temperatures and humidity. Streams of moist air are then force-circulated through the timber stack with a temperature initially slightly higher than the normal. The temperature is then steadily increased and the humidity proportionately reduced. In this way, the cell fibres are made to yield their moisture at a greatly accelerated rate, so much so that a 1 in. board of abura, for example, can be dried out to a required moisture content within a period of two to three weeks.

The advantages of the use of this method are obvious in relation to the practice of using air-dried stock, but all too many of the smaller manufacturers in the industry fail to grasp the ultimate financial advantage which this method must yield. Naturally, the smaller manufacturer cannot afford to build and maintain these expensive structures, but there are a very considerable number of timber importers who already have this equipment and who carry out the work involved at rates which are on a national agreed basis.

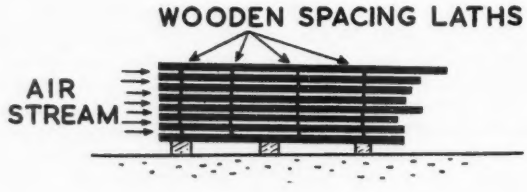

Fig. 3.

plywood

Plywoods are secondary only to timber in importance to the furniture industry. Indeed, the surface area of any piece of domestic furniture normally contains very much more plywood than solid timber. For example, a wardrobe has a total surface of about 53 square feet. Of this quantity there will be not more than 12 square feet of timber with 41 square feet of plywood.

In very many respects plywood is superior to solid timber, particularly in stability, in strength, and in price. The latter factor is of primary importance, since the entire basic price structure of furniture in this country would be increased by at least 25% if plywood was replaced by solid timber.

The physical advantages of plywood over timber of similar dimensions are not generally appreciated since, unfortunately, a large section of the population still thinks of plywood in terms of tea chests. However, plywood as opposed to solid timber is an extremely strong and stable material. Its strength can be very simply illustrated by comparing a load test on a piece of solid timber $\frac{1}{4}$ in. thick by 3 in. wide with a piece of plywood of similar dimensions. As the load is applied to the timber the fibres of the concave face are in compression, whilst those of the convex face are in tension. As the load increases, the deflection of the plank is proportionate to the load until a critical point is reached when the deflection increases more rapidly than the load and fracture occurs on the convex face (Fig. 4).

Plywood, on the other hand, is built up of laminations in such a manner that the grain of each lamination is at right angles to its neighbour. The crossing of the grain in this manner thus gives the material the greatest possible strength in both directions of the grain. Plywood is, in actual fact, many times stronger than the strength of the laminations measured individually, through:

(a) the cross-graining of the laminations; and

(b) the adhesion through gluing of each lamination.

The same load test applied to the timber specimen above would thus not create any fracture whatsoever in a similarly proportioned plywood specimen. Furthermore, the plywood, by virtue of its lamination strength, would regain its original position when the load was removed.

The tendency to shrink or expand is also very much more restricted than that of a solid piece of timber, since its movement is controlled by two factors:

(a) the laminations are dried out to a very low moisture content before manufacture;

(b) the laminations are fully bonded to each other

Thus, from a purely physical point of view plywood is undoubtedly superior to timber for

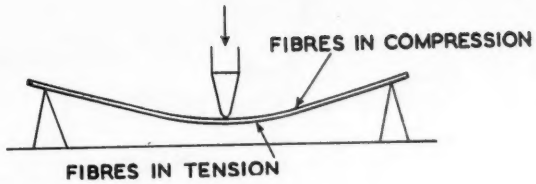

Fig. 4.

work which requires large areas to be covered by material of relatively thin section. Unfortunately, most of the commercial types of plywoods do not have attractive or decorative figure characteristics. A piece of furniture in which plywoods are used is therefore made attractive and decorative by the use of veneers on these plywood panels.

veneers

As has been indicated in preceding sections, the furniture industry depends largely upon "substitute" hardwoods and on plywood for the current manufacture of modern furniture. Neither of these materials — in the normal commercial grades — can compare with the beauties of, for example, finely figured oak or walnut, which, apart from being in short supply, are extremely expensive materials in relation to the other two commodities. The manufacturer therefore employs the practice of veneering in order to enhance the quality of his goods, and to make them attractive in the home to the ultimate buyer.

Again, a large section of the general public deplores the practice of veneering and feels that it is allied to shoddy manufacture. It must be admitted that there are limited grounds for this supposition, because undoubtedly a great deal of shoddy work was turned out during the slump years and during the early part of the War. Veneering, however, is an economic necessity in this day and age and, furthermore, is a medium which does provide a definite attraction in the appearance of the finished product.

Veneering is by no means a modern innovation. The practice was used as far back as the day of the Pharaohs and has been continually in use by master craftsmen in Europe for the past 300 years.

The veneers are cut from the rarer types of wood in the form of logs, roots, stumps, boules or burrs. It is perhaps interesting to note that the greater the disfigurement of the tree through bends or twists, the more magnificent is the figure obtained when the veneer is cut. Many different methods are used to cut the veneer in such a way as to present the most attractive figure and amongst the more popular means are slicing and half-round cutting. Fig. 5 illustrates how these operations are carried out.

The veneers are normally imported into this country in a ready cut condition and, after purchase by the manufacturer are fixed to the plywood

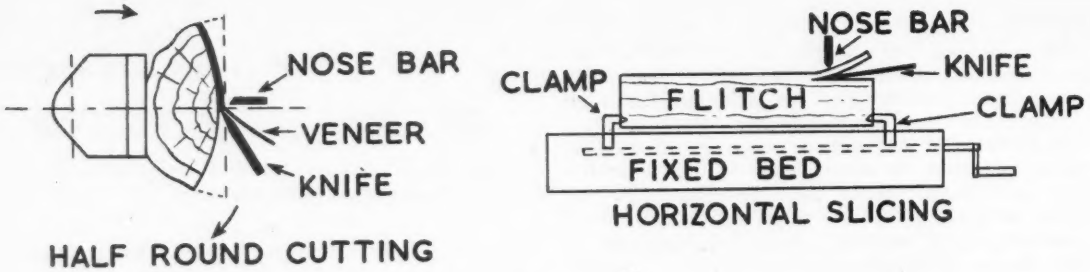

Fig. 5.

panel by gluing under pressure. The gluing of this veneer to a piece of plywood upsets the "balance" of the forces in the cross-grained laminations of the plywood. In order to avoid the resultant twisting, the furniture manufacturer compensates this action by simultaneously gluing a cheaper "backing" veneer to the other face of the plywood.

blockboard

Blockboard is a material akin to plywood in its physical attributes, but which is cheaper than plywood in thicknesses of $\frac{1}{2}$ in. or more. Briefly, blockboard mainly consists of two outer laminations with a centre core made of strips of softwood. The material is normally used in the doors of wardrobes and sideboards and, occasionally, in the manufacture of dining room table tops (Fig. 6).

laminated wood

The term laminated wood is normally applied to timber laminations which have been glued and pressed to a predetermined shape. An example of the use of this medium is illustrated in Fig. 7, and its advantages both in strength and in cost can be readily appreciated if one considers the comparative cost of producing the same shape from solid timber.

The main deterrents from the manufacturer's point of view are two-fold. The first of these is that it is necessary to employ high frequency electric heating to accelerate the gluing time required, and such equipment is relatively costly. Secondly, the items of furniture so far produced by these means have not been singularly successful from a selling point of view — possibly because of the inherent antipathy towards plywood by the public as mentioned in preceding paragraphs.

Again, as in the case of veneering, the method is not new since, for example, laminated wood has been used in the rims of grand pianos for the past 100 years. With the ever-increasing costs of timber and the increasing demand for less heavy and equally robust furniture, there is no doubt that this material must steadily gain ground in popularity during the course of the next decade. The growth of its popularity depends solely upon the ingenuity of the designer to produce more tasteful, attractive, design forms, and the education by the manufacturer of the retailer and the buying public of the advantages to be gained from this form of construction.

melamine plastics

The use of these materials under such household names as Formica or Warerite has gained tremendous popularity in recent years, and rightly so, because of their very definite advantages over timber, plywood or veneers, in durability and surface strength. Their use has been confined principally to kitchen furniture up to the present, but there is no reason why they should not be incorporated into other "working" surfaces such as dining-room table tops or sideboard tops. This practice will come inevitably when the manufacturers are able to :—

(a) reproduce faithfully a natural timber pattern;

(b) develop a more ductile material which can be readily moulded to any reasonably functional shape;

(c) reduce the basic price of the commodity to a level more approximately that of decorative veneer.

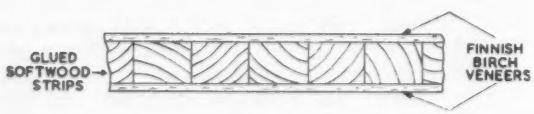

Fig. 6.

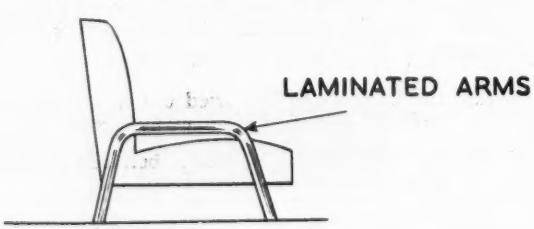

Fig. 7.

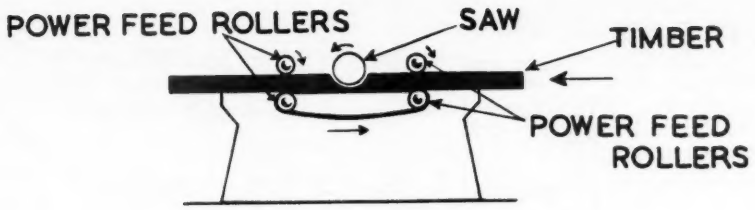

Fig. 8.

The manufacture of these plastic materials is basically a relatively simple operation and consists of the fusing together under heat and pressure of several layers of paper impregnated with a melamine resin, the top paper having the coloured pattern which is evident on the finished product.

plant and equipment

(a) machine shop

(i) *conversion machinery*

As has been indicated in the section dealing with hardwoods, the material arrives at the factory in sawn boards. It is then converted into the nominal lengths and widths of the piece part prior to further machining. Each of these operations is carried out by high speed rotary saws. The operation of cutting to nominal length is carried out on a cross cut saw which, as the name implies, cuts across the grain. One machine used has a foot-operated hydraulic feed which permits a board 24 in. × 3 in. to be cut in under two seconds cutting time.

After cutting to length, the pieces are then passed through another saw known as a straight line edger, with a longitudinal power chain feed which forces the material past the saw at feeds between 50 and 180 feet per minute, depending upon the species and thickness of the boards. Fig. 8 illustrates the operation of the machine.

(ii) *basic production machinery*

The stock, having been converted to nominal dimensions, is now ready for succeeding operations which, of course, vary according to the finished section and shape of the piece part.

The most important of the production machines is a combined planing and moulding machine known as a 4-cutter or a 5-cutter, according to the number of motorised heads incorporated in its construction. The object of this machine is fully to machine all four surfaces of any straight stock to virtually any required section. Fig. 9 gives a broad indication of the operation of the machine and shows the position of the various cutter heads, which are used at speeds of up to about 7,000 r.p.m. As in the case of a straight line edger, the machine is power fed and is normally equipped with power feed rollers which pass the stock through the machine at feed rates of up to 120 feet per minute.

The next most important machine on the mass production line is a double end tenoning machine. The purpose of this machine is basically simultaneously to cut tenons and cut both ends of the piece to length in one operation. It carries out more operations at the same time than any other piece of woodworking machinery and may include as many as two circular saws, four horizontal cutters and eight vertical cutters. Again, this machine is invariably equipped with a power chain feed which carries the work through the cutters at a feed rate of up to 40 feet per minute.

As can be readily appreciated, the speed of output from this machine in terms of piece parts is phenomenal and is, to a certain extent, a drawback, in that it has to be far more frequently broken down and re-set for succeeding batches of parts than any other of the woodworking plant. Fig. 10 shows the basic operation of the machine.

The machines dealt with above are concerned entirely with straight stock and do not play any

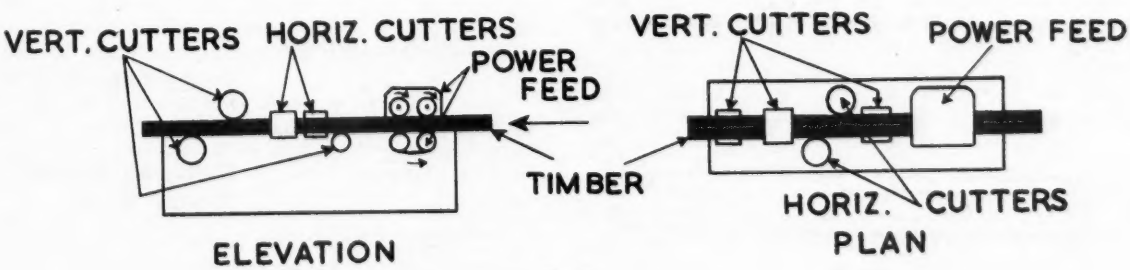

Fig. 9.

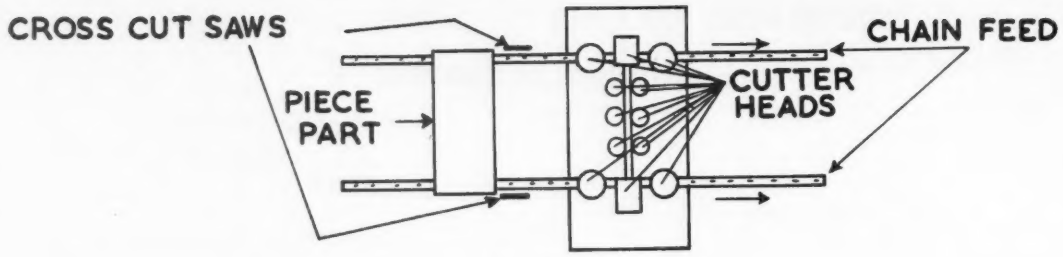

Fig. 10.

part in the finish machining of shaped or curved stock. The majority of this work is carried out by single spindle machines, the two of which in most common use are called a router and a spindle moulder.

The router has a cutter mounted above the work table in much the same way as a vertical milling machine. The cutter head works at a very high speed within the range of 18,000 to 25,000 r.p.m. It is normally used for shaping, rounding, or moulding both outside and inside curves and can be used for most forms of carving. Because of its very high speed and normally small diameter cutter, the quality of finish obtained is usually very high and requires very little hand finishing.

The spindle moulder is the maid-of-all-work in the woodworking industry and consists of a vertical revolving spindle projecting through the centre of the work table. It can be used for the machining of straight or curved, singlesided, or edge mouldings of all kinds including grooves and rebates. Its versatility is further increased with the use of specially designed attachments which permit work to be dovetailed, or tenoned, on the machine. The cutter speeds are necessarily lower than the router because of the wide range of work which this machine undertakes, and are usually within the range of between 4,500 and 9,000 r.p.m.

(iii) *finishing machinery*

The fundamental principle of wood machining is to cut with the grain and not across the grain. Thus, each of the pieces of production machinery referred to is designed so that the cutter operates with a rotary action in line with the grain. In turn, this action causes the surface to be rippled as illustrated in Fig. 11.

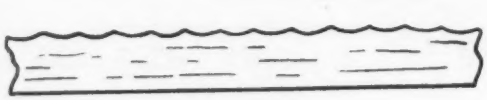

Fig. 11.

The rippling action—although not always clearly visible to the naked eye—shows up quite clearly when the work is polished to a fine gloss finish. It is therefore necessary to eliminate these ripples and this is achieved by the use of motorised sanding machines.

The most important of these is known as a triple drum sander, and consists of three drums covered with sanding paper and mounted above a rubber faced endless chain belt which automatically feeds the work under the drums. The height of the drums above the work can be finely adjusted and it is normal for the first drum to take the heavier cut, and the second and third drums proportionately finer cuts. In the same manner, the grade of grit used in the sand paper of each drum is progressively finer. The second and third drums are provided with an oscillating movement in order to prevent any scoring on the finished surface by a "build up" of wood dust on any one part of the rollers (Fig. 12).

For even finer finishing — particularly on veneered panels — a machine known as a belt sander is used. This machine consists fundamentally of an endless sanding belt running horizontally over the work table. The table is mounted on roller bearings running on tracks which enable it to be slid backwards and forwards along these tracks. The work is placed on the table and moved to and fro under the continuously moving belt, which is pressed down to the sanding surface by a pad which is manually slid from side to side on steel runways.

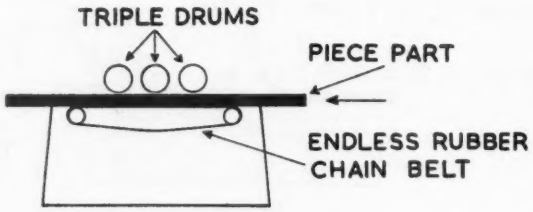

Fig. 12.

(b) assembly shop

The basic methods of assembly are still very much akin to those used by the earlier craftsmen but their time cycle has been speeded up by

(a) the more accurate machining of piece parts;
(b) the development of quick acting synthetic resin cements;
(c) the use of pneumatically operated jigs and fixtures.

The point regarding piece parts is readily appreciated when one considers the great strides which have been made by the machine manufacturers in providing high speed machinery designed specifically for the accurate reproduction of piece parts. Unfortunately, not every furniture manufacturer has appreciated the need for strict quality control under modern circumstances, but the realisation for this need is growing as the advantages are realised.

The development of synthetic resin cements has reduced very considerably the time cycle required for the hardening and setting of the adhesive in, for example, a complete carcase assembly. Apart from the reduction in time, the synthetic resin cements now provide a joint very much stronger than that of any of the natural traditional glues. Development of these materials is a continuous process and it is quite probable that before very long it will be possible to butt-joint the pieces of wood together so firmly and so securely that the need for the traditional types of joint, such as a mortice and tenon, may be completely eliminated. Such a development would have a far-reaching effect upon the furniture industry and, indeed, upon the ultimate selling price of the product, since it would then not be necessary to install and maintain such expensive machinery as that required at this time for tenoning and morticing.

The use of pneumatic equipment has grown very considerably in the industry in the last 25 years because of its suitability for the quick and sustained application of pressure. In most pure assembly operations, pressure must be applied firmly to glue the joints of each piece part in the assembly. For many, many years the pressure was obtained by the use of a sash cramp which, in effect, consists of an adjustable bar with a lead screw at one end which is turned to apply the pressure. Wherever practicable the sash cramp has now been replaced by pneumatic cramps, and pneumatically operated fixtures have now been evolved which permit the whole of a wardrobe body to be assembled and pressed in one-fifth of the time taken by traditional methods.

The smaller sub-assemblies are normally carried out on a steel cramping table, which has longitudinal grooves spaced some 8 in. apart and which is equipped with between four and eight pneumatic cramping heads. The location jig is secured to the table, and the pneumatic heads are adjusted to apply the pressure at the required points. Other minor assemblies are carried out on jigs or fixtures equipped with toggle clamps or simple cam clamps.

(c) polishing shop

Virtually no furniture today — particularly in the popular market — is polished by traditional hand polishing or "French Polishing" methods. The bulk of the industry now utilises cellulose-based materials, the finishing coats of which are applied by spray gun, or other mechanical means. The operations sequence on normal polished furniture is as follows:

(i) *stain filler*

The stain filler is a paste with a cellulose base which permits the open grain pores to be filled and, at the same time, stains the whole surface to a reasonably uniform colour. (It is necessary to fill the grain in order to achieve a full gloss finish). The paste is applied by hand and is rubbed into the timber or veneer by a portable machine which consists of a motorised spindle fitted with flexible blades, which rotate against the surface and press the filler firmly into the grain material.

(ii) *cut down*

The moisture in the filler causes the surface fibres of the timber to lift, and it is necessary for these to be removed by the application of abrasive paper. This operation is carried out by another portable piece of electrical equipment, which consists of either one or two flexible pads operating at high speed with a reciprocating motion.

(iii) *sealing*

Timber is always affected by changes of moisture content in the atmosphere. It is therefore necessary to seal the whole surface in order to prevent absorbtion of moisture by the finished product. The sealer is a transparent cellulose material and, in this instance, is applied by spray gun.

(iv) *cut down*

Again, the moisture of the sealer coat causes fibres to rise — albeit in lesser proportion. It is therefore necessary for the whole surface to be very lightly rubbed down — normally by hand — with a very fine grade of abrasive paper.

(v) *matching*

Due to the differences in density of the grain in the various members and panels of a piece of furniture, the stain filler shows up some degrees lighter in certain places than in others. In order to obtain a fully uniform colour throughout, it is necessary to apply a mist of liquid stain to the lighter patches. This operation is carried out by another finer type of spray gun which emits a very fine and delicate spray mist.

(vi) *lacquer*

Clear cellulose lacquer is then applied by spray gun and normally consists of a double coat applied wet on wet.

(*concluded on page* 205)

sub-zero temperature refrigeration of materials

by R. L. LEE

WITH the growing need to improve productive efficiency in order to meet the ever-increasing trend of world requirements, the demands on production development in all fields of industry has made necessary the fullest exploitation of all known and recently developed aids to production techniques. In addition, the advent of new materials and by-products requires still further extensive investigation to discover the best and most economical methods of working to meet evolution requirements.

In view of strides already made in this direction, it is rather surprising that so little attention has been given, by production engineers in the U.K., to the many profitable possibilities offered by the application of sub-zero temperature refrigeration. Such techniques are already being used widely abroad and applied in a variety of industrial fields notable among which are metallurgy, chemicals, plastics, pharmaceuticals, rubber, petroleum, instrument testing, and assembly work—in all cases remarkable and phenomenal results being obtained.

It is proposed to give in this Paper a practical introduction to the subject of sub-zero temperature refrigeration and to illustrate how such processes may be advantageously applied to many production problems and techniques.

Sub-zero temperature refrigeration, or deep-freeze as it is otherwise known, is a comparatively new process, the results of early 20th century science. During experiments then carried out in the subjecting of various materials to sub-zero temperatures, it was discovered that changes took place on certain steel test pieces with regard to hardness and magnetic properties; what actually occurred however, was not established until the later advent of better scientific instruments. It was then found that truly phenomenal structural changes took place in materials subjected to the treatment. The earlier discoveries lapsed somewhat into obscurity due mainly to the fact that :

1. the artificial creation of the necessary low temperatures was very expensive; and
2. little was known as to the actual effect of the low temperature on the metallic grain structures.

It is known, however, that occasional use of the process has been made by Germany during the last 25 years and by America for the past 20 years.

With the advent of World War II, active investigation and development was given to the process and today equipment has been designed to produce easily and economically temperatures to as low as –150°F. Also, sufficient knowledge and experience have been gained to assess the basic potentialities of the treatment.

In general, the use of deep-freeze refrigeration has been the subject of much speculation and whether or not the treatment can produce advantageous results is a question in the minds of many. Possible causes of doubt may be attributed to the fact that in the initial

stages of development and usage many remarkable results were claimed by some users, but not achieved by others—possibly due to unscientific approach or wrongful application. It is possible that low temperature refrigeration has certain limitations, but what these limitations are cannot be definitely determined at the present time. The full extent of its potentialities remains unexplored and current investigations are revealing many other valuable features in its ever-broadening field. It will be appreciated then that although a great deal of information has been discovered about the process, much ground still remains to be explored by enterprising industries.

Chief of the many industries to benefit greatly by sub-zero refrigeration is that of engineering where valuable contributions indeed have already been made to processes such as hardening, stabilisation of alloy steels, ageing of castings, production of investment castings, work and gauge salvaging, assembly by shrinking, and prolongation of tool life. This Paper will refer to these applications.

what happens to treated metals

In order to appreciate the full effect of sub-zero temperatures on tool steel, it is necessary to have some understanding of the fundamental principles of the heat treatment process, and of the structural changes which occur in the metal during such treatment. Briefly, when the steel is subjected to heat treatment certain transformation characteristics occur between the iron, carbon, and alloying elements of which it is composed. When heated above what is known as its critical temperature, these elements blend together into a solution, forming austenite. If it is now allowed to cool slowly from this state, the material will automatically revert to its original structural condition but, if cooled quickly by immersion in a cooling liquid, it will partially develop a structure known as martensite, which is the main constituent of hardness. It is most desirable, in the hardening of steels, to form a structure composed principally of martensite which slowly forms at relatively low temperatures in the course of its cooling. Thus, for example, a steel which reaches the austenitic state at a temperature of 1500° F may have its martensite transformation starting at 500° F during its quenching cycle, the state of transition increasing rapidly on the cooling process reaching near room temperature. The determination of the

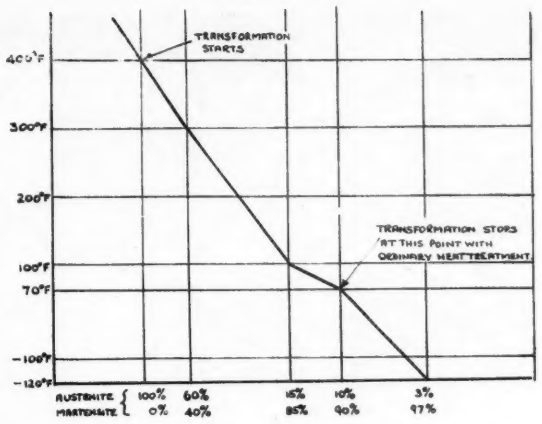

Fig. 1. Transformation curve of austenite to martensite in alloy steel at temperatures varying from 400°F to -120°F.

temperature at which the martensite transformation actually commences in the various types of alloy steels can be ascertained quite easily, but the temperature at which it ceases has not yet been really established. Investigations into this subject have proved that transformation of martensite in certain alloy steels is evident even at temperatures as low as –250° F.

It will be evident, then, that with ordinary heat treatment methods, the decomposition of austenite stops when a steel reaches room temperature and that temperatures lower than this could be advantageously applied to bring about a more complete transformation. Thus it has been established, by applying combinations of standard heat treatment and sub-zero temperature treatment, that increased combinations of hardness, strength and ductility are obtained.

Originally concern was expressed as to whether or not the sub-zero treatment, whilst increasing the hardness of an alloy, would also make it too brittle. Doubts were soon dispelled when it was proved by impact tests that in addition to hardness, ductility was in fact also considerably improved. It was also established that the degree of hardness developed was retained up to temperatures as high as 1050° F.

at what temperatures must metals be treated?

Although much information and data exists for many applications, it should be appreciated that the

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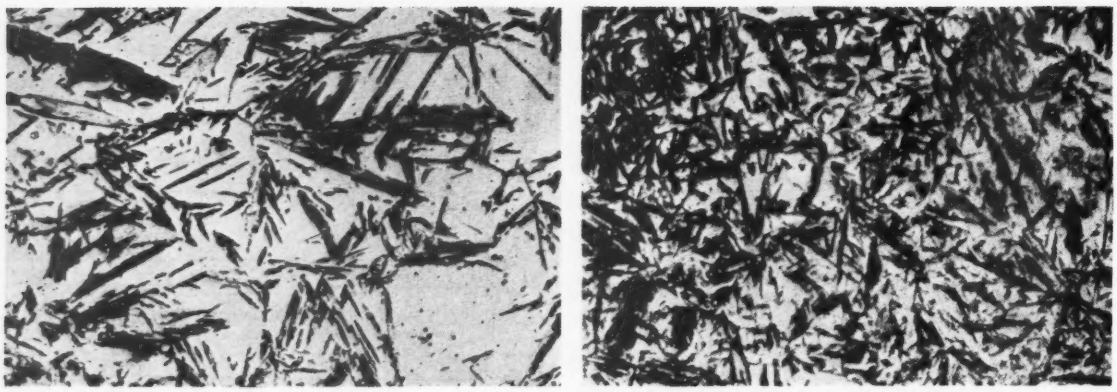
He is the author of a number of published works and is at the present time a Plant Engineer with D. Napier & Son Limited, London.



A B

Fig. 2. Sample A shows martensite and retained austenite in a specimen subjected to normal heat treatment. Sample B shows a similar specimen after two cycles of treatment followed by tempering, and illustrates that the austenite has almost disappeared.

exact sub-zero temperature at which metals should be treated will vary with the type of equipment and techniques employed. In the main temperatures between –100° and –120° F will be found suitable for general work, whilst temperatures in the region of –70° F are practicable for shrink fitting work.

time of treatment

The treatment time again will vary according to the mass and type of material used. For both ferrous and non-ferrous metals cycling operations — alternately subjecting the parts to the tempering temperature, room temperature and sub-zero temperature — are required in order that the stabilisation of parts can be completely carried out. From two to five cycles are recommended, dependent on the degree of stabilisation required, the final cycle finishing with a tempering temperature of between 200°F and 300°F.

In all cases it will be necessary for a component to be given a sufficient allowance of time in the deep-freeze equipment to ensure that dissipation of heat from the component mass takes place. Thus, supposing it is required to reduce a steel component of 42½ lb. weight from room temperature (70° F) to a temperature of –120° F the heat to be dissipated is :–

$$\begin{aligned} \text{Mass} \times \text{Specific Heat} \times \text{Temperature Drop} &= 42.5 \times 0.117 \times (70 \text{ to } -120) \\ &= 42.5 \times 0.117 \times 190 \\ &= 940 \text{ B.T.U.} \end{aligned}$$

If then a deep-freeze refrigerator with a heat absorbtion capacity of 1000 B.T.U. per hour at –120°F is used, the natural heat will be dissipated from the part in an hour, approximately. Hence, in addition to this time, a further one-and-a-half to two hours will be required to allow transformation of the austenite content to take place.

some examples of results achieved by deep-freeze refrigeration

In the examples now given are included some of the results achieved by deep-freeze refrigeration by prominent manufacturers in the U.S.A. These results have been made available to the author through the courtesy of the Sub-zero Products Co. of Ohio.

Probably one of the most outstanding results achieved is the case experienced by a manufacturer contracted to supply ball bearings for work of military importance. The bearings to be supplied were to be subjected to an instant change of inertia from 0 to 18,000 r.p.m. which they were not able to withstand — the balls Brinelling into their races.

In order to overcome this experiments were carried out with sub-zero treatment, the bearings, after hardening, being tempered and allowed to cool to 150°F before again being subjected to –120°F, after which another draw was made. The result was a Rockwell "C" scale reading of 67½ - 68 with a grain structure that was very fine and lapped excellently.

The bearings thus treated (which were of S.A.E. –52100) were not only able to withstand the Brinelling action caused by the severe acceleration, but also experienced no dimensional changes when subjected to varying temperatures.

stabilisation

The use of deep-freeze refrigeration makes a valuable contribution in the stabilisation of precision components such as gauges, machine parts, arbors, and aircraft bearings. By completing the transformation of the retained austenite in the initial stages, dimensional changes, which would otherwise occur in the metal over a period of time, are prevented. Such changes are so great that gauge blocks have

been known to increase their tolerance by as much as 20 times over a period. Previously, these changes were overcome by partially machining the parts and then ageing them by outdoor exposure for several years before final machining. Today, such results can be achieved, by use of deep-freeze, in a matter of hours, allowing such work to be produced on a more dependable and economic basis.

Another resultant feature of applying the method is the marked increase in the wear resistance qualities of the treated part.

By using the following procedure, a well-known gauge manufacturer produces gauge blocks with a resultant stability of within 0.000002 in. The part is rough ground to within 0.002 in. and then subjected six times to a temperature of –120° F. After each application it is allowed to return to room temperature, the length of each immersion in the deep-freeze being sufficient to allow complete penetration.

The test for stability laid down by the U.S. Bureau of Standards consists of boiling the part in a 1% solution of potassium dichromate in water, for 24 hours. If the part deviates in dimension by more than two millionths of an inch, it is not considered stable. Such tests are regularly carried out by users of the deep-freeze process at their own works.

Particular requirements for stabilisation are found in aircraft components where close limits are essential. Components machined by normal methods will often seize up at the higher altitudes. If such parts are, however, subjected to sub-zero temperatures prior to finishing they will accomplish their work much more satisfactorily, with a very much reduced chance of seizure.

Cast iron and other steels are among the few of the various metals which can be successfully stabilised. Particular advantages are also gained by any other metal subjected to heavy loads or extreme temperature changes. In the case of non-ferrous metals such as aluminium and magnesium castings, although no physical changes take place, all stresses and strains are duly relieved within the structure by way of the process; hence, machining can be done with little possibility of distortion. The treatment of such parts consists of subjecting them to alternate temperatures of –120°F and 212°F, the parts each time being allowed to return to room temperature before going into any of the opposite temperatures.

An interesting example of sub-zero application for stabilisation is that experienced by Canadian Westinghouse*. Considerable trouble was caused by aluminium castings " moving " during operations and a procedure was decided upon to eliminate such trouble. This consisted of rough machining all over leaving 0.032 in., the parts then being left to age for 24 hours. Further machining then took place leaving 0.010 in., the parts again being allowed to age for a further 24 hours before final machining to size. Now, by application of deep-freeze before machining it is possible to complete the work in one set up — rough machining to 0.015 in., followed immediately by finish machining.

Alloy steels can only be successfully stabilised after the following three conditions have been achieved :–

* *American Machinist*, 30th January, 1956.

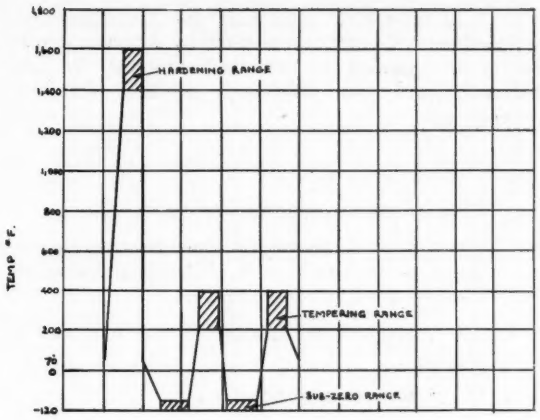


Fig. 3. Typical cycling in the treatment of tool steel.

1. the parts must be correctly hardened by proper heat treatment methods;
2. complete transformation of the austenite to martensite must be obtained; (it is the untransformed portion which causes the increased dimensional changes to occur over a period of time).
3. the martensite must be thoroughly tempered.

Final finishing of the part is undertaken after the martensitic condition is reached, the final tempering draw relieving the inherent stresses.

During the sub-zero application it has been found that best results are achieved by preventing the part from being held at room temperature for any appreciable length of time. It has been found that delay in temperature drop causes a slight stability in the austenite content, this phenomenon increasing the difficulty of its further transformation.

TEMPERATURE CONVERSION TABLE, DEGREES CENTIGRADE TO DEGREES FAHRENHEIT

C°	F°	C°	F°
90	194	0	32
85	185	–5	23
80	176	–10	14
75	167	–15	5
70	158	–20	–4
65	149	–25	–13
60	140	–30	–22
55	131	–35	–31
50	122	–40	–40
45	113	–45	–49
40	104	–50	–58
35	95	–55	–67
30	86	–60	–76
25	77	–65	–85
20	68	–70	–94
15	59	–75	–103
10	50	–80	–112
5	41	–85	–121

It is of interest to note that the stabilisation of stainless steel aircraft components by sub-zero application is specified as standard practice by the U.S.A.F. and the following is the standard procedure :–

1. Heat treat as specified.
2. Chrome plate as specified.
3. Immediately following plating, heat to a temperature of 390° F to 410° F for a period of two-and-a-half to three hours.
4. All machine dimensions to be held after plating.
5. Grind to size as specified.
6. Stabilise by lowering temperature of part to –120°F. Hold that temperature for one-and-a-half hours. Allow part to return to room temperature in still air. Heat to 400°F, hold at temperature for one-and-a-half hours. Allow part to return to room temperature in still air.
7. Lap and code.

high-carbon, high chrome and carburised tungsten shock steels

Such steels, being very highly alloyed, have characteristics that make them most reluctant to martensitic transformation and often show low hardness readings after heat treatment. Sub-zero treatment, therefore, has particular value in the satisfactory treatment of work made of these materials.

Extensive use is made of such alloy steels in the production of drawing tools, press tools and cutting tools where high hardness and toughness are essential features. Any retained austenite in such tools results in earlier wear or breakdown than that which would be experienced in suitably heat-treated tools, as austenite possesses rapid work-hardening properties which accelerate the development of any cracks produced during working action. The greater the martensite structure, the lower the possibility of cracks arising, with consequent longer tool life.

The sub-zero treatment of steels of the above type consists of subjection of the component, after the normal heat treatment, to a temperature of –120° F or, if possible, lower, for a period of two to four hours, when a response of Rockwell hardness of from four to six points can be expected. It is normal practice, before making the Rockwell test, to subject the work to a draw of 200° F to 300° F for a period of one to two hours, on its return to room temperature, as there is a tendency to crack through the Rockwell impression, due to the newly formed martensite not being stabilised. Certain companies have found that using a double temper with sub-zero treatment before each operation produces most satisfactory results. In one instance, a manufacturer using such a process on a set of dies found that components were then produced at the rate of 62,000 pieces between grinds, as opposed to 20,000 per grind as experienced previously.

In the case of the carburising steels a most satisfactory response to sub-zero treatment is experienced.

Generally it is the reaction, on finding a suitable core hardness has been obtained but that case hardness is below specification, to reduce the hardening temperature to a point where dispersal of the austenite content will take place. This procedure will, however, result in a decrease of the core hardness. By use of sub-zero treatment it is possible to achieve both desirable results. This may be accomplished by subjecting the part to a temperature of –120° F for a period of two to three hours, after the necessary core hardness has been obtained. An increase in the case hardness of from five to 15 points Rockwell "C" will be found, after finishing with a slight draw.

In a Paper prepared by H. E. Boyer, Chief Metallurgist of the American Bosch Corp.,* the writer mentioned tests carried out on the sub-zero treatment of five types of alloy steels of chemical compositions, as shown at the top of the next page.

The resultant data was compiled through the checking of a quantity of specimens, a different set of specimens being used for each phase of temperature readings given; thus, no set was given more than one cold treatment. The readings were made on ground and polished surfaces of the pieces, and the machine on which the checks were made was checked for accuracy after every five readings.

The I.C.I. "Cassel" Manual of Heat-Treatment and Casehardening also gives some results of the improved hardnesses obtained by use of "Drikold", to obtain sub-zero temperatures, as set out in the third table opposite.

prolongation of tool life

Many spectacular increases in cutting efficiency and tool life have been recorded on tools such as taps, reamers, drills and milling cutters, after they have been subjected to the treatment.

One case in point is the treatment, by a prominent machine tool manufacturer, of high speed drills used to drill four 11/32 in. diameter holes in a yoke lever part made of a molybdenum steel forging with a Brinell number of 387. The machine used was a special twin spindle opposed head type and a spindle speed of 450 r.p.m. was used for the particular job, with a feed rate of five in. per minute. Before treatment the best possible performance of the drills was 48 holes before regrinding. After cold treatment for two hours at –120° F the average results were 256 holes before regrinding was necessary — an increase of 500 per cent. Other random cases are as follows :–

1. Standard milling cutters, in a gang of three, machining a S.A.E. 4340 steel forging of Brinell 387 to 402. Cutters are two 8 in. dia. and one 9 in. dia. running at 15 r.p.m. with a feed of $\frac{1}{2}$ in. per minute. Before treatment the cutters had to be sharpened every seven hours, but after treatment it was

* *The Iron Age*, February, 1948.

Type	*C%*	*Mn.%*	*Co.%*	*Mo.%*	*W.%*	*V.%*
A	1.04	0.28				
B	1.05	0.30	1.42			
C	0.72	0.32	4.10		17.90	1.05
D	2.05	0.30	11.75	0.80		0.20
E	1.07	0.36	17.20	0.48		

The results of such tests were as follows :–

Temperature	*Hardness Rockwell "C"*				
F°	*Type A*	*Type B*	*Type C*	*Type D*	*Type E*
75	66	65	64	65	60
50	66	65	64	65	61
25	66.5	65	64	65	61
0	66.5	65	64.5	66	61
–25	66.5	65.5	65	66	61.5
–50	67	65.5	65	66.5	61.5
–75	67	66	65	67.5	62
–100	67	66	65.5	67.5	62
–125	67	67	66	68	62
–155	68	67	66.5	68	63

Material	*Condition*	Vickers Hardness (30 kilo load)		
		Before cooling	*After cooling to -105°F and return to room temp.*	*Average hardness increase*
B.S.En 31 1% carbon chrome steel	As hardened from 830°C in oil	862-866	908-927	49
Manganese non-deform tool steel	Hardened from 800°C in oil	750-757	802-867	80
B.S.En 33 3% nickel case - hardening steel	Carburise in 'Rapideep' at 930°C. Reheated 780°C and oil quenched	725-750	810-874	104

only necessary to resharpen every 24 hours. Treatment was two hours at –120° F.

2. Average life of taps was 40 pieces — treated taps now average 500 pieces.
3. Gear cutting hobs produced 150 pieces per grind — treated hobs average 710 pieces.
4. Molybdenum high speed hacksaw blades, used in cutting $5\frac{3}{4}$ in. dia. Meehanite cast bars, now last twice as long after treatment.

reclamation of tools and gauges

The phenomenon of growth occurring in the types of steels used in the production of tools and gauges can be profitably used in the reclamation of such tools, where only small dimensional wear has occurred. By subjecting them to cold treatment a small build-up can be obtained, due to the completed austenite/martensite transformation. The work then can be checked for size and, if build-up has taken place, can be finished off to original size by grinding or lapping.

expansion fitting

Expansion-fit assembly is probably the oldest and most extensively used application of sub-zero temperature, the method used having greater advantages over the conventional practice of fitting by thermal means, and that of assembly by pressure

In general shrink fitting work the female part is expanded under heat, this then being allowed to contract over the male portion on to which it has to be fitted. During the course of such heating, distortion and oxidisation usually occur and it is necessary for finish machining to be done, after assembly, to bring the part to finish size. In order to offset this type of distortion and eliminate the

consequent machining, mating parts, wherever possible, are machined to recommended interference fit tolerances and then forced together under pressure.

Expansion fitting eliminates all attendant difficulties experienced in either shrink or force fitting methods and is carried out by merely shrinking the male portion, by sub-zero refrigeration, inserting it into the female portion and then allowing it to expand to fit at room temperature. This method has several advantages, viz :–

1. heat distortion is avoided;
2. cleaning and final machining after assembly are eliminated;
3. cold parts are easier to handle, hand pressure only being necessary; the use of presses or pounding is eliminated, hence possible distortion by any of these means is avoided;
4. firmer bonding is assured, and tests have shown that this type of fit is capable of withstanding pressures up to ten tons.

Shrinking of metal at –70° F to –120° F makes possible the assembly of sleeve bearings and ball or roller races on a more economic basis. By freezing and then slipping them into position alignment is assured, thus the possibility of bearing removal, due to misalignment, is disposed of.

shrinking

In general, when applying the sub-zero refrigeration method of shrinking the same tolerances of interference fit sizes can be used as those of previous methods.

The approximate shrinkage of various metals, at –70°F and –120°F per 2 in. of diameter, is shown below :–

Metal	*–70° F*	*–120° F*
Tool Steel	0.0016	0.0026
Phosphor Bronze	0.0024	0.0036
Aluminium Bronze	0.0024	0.0036
Brass	0.0028	0.0040
Aluminium	0.0034	0.0046
Magnesium	0.0034	0.0047

Other diameters shrink proportionately.

For quick calculations it is generally the rule to assume that tool steel will shrink about 0.001 in. for each inch of diameter when chilled to –120°F; bronze and brass shrink about 0.0015 in. per inch of diameter. Aluminium and magnesium shrinkage is about 0.002 in. per inch. These same dimensional changes can be accomplished in the other direction by a 200°F rise in temperature. Should sufficient shrinkage not be achieved on the male part due to small diameter or excessive interference requirements, it is practicable to heat the female part causing it to expand. If this should be found necessary, however, care should be taken that the intensity of heat is not great enough to cause warping. Usually a temperature of just above 212° F is sufficient to obtain the necessary expansion. If the female part is of such proportions as to make heating all over impracticable, a plug type induction heater, applied to the bore, is recommended.

Some interesting examples of expansion fitting work practised by leading manufacturing plants are :–

1. Aeroplane landing struts, requiring a permanent shrink fit, were formerly assembled in 20 minutes. By expansion fitting the time has been reduced to 10 minutes. This is done by heating the female part in an oil bath at 450°F producing an expansion of 0.005 in. The male part is shrunk 0.005 in. at –120°F. Time in oil bath — five minutes ; time in deep-freeze — five minutes. Cooling time to room temperature — five minutes.
2. Difficulties were experienced by a diesel engine manufacturer in the fitting of bronze bushings into connecting rods because the bearings had to be inserted and removed three times, this procedure being necessary because the bearings had to be machined both while in and out of the rods. The fitting of the bush was accomplished by expansion fitting, the time in respect to the previous method being considerably reduced.

   Removal of the bush was accomplished by making a sheet metal container, of outside diameter smaller than that of the bush bore and provided with a screw plug. The chamber was then filled with a solution of methylene chloride (chilled to –120°F) and placed inside the bush. Within four minutes the bearing fell out.
3. An aero engine manufacturer now uses expansion fitting in conjunction with induction heating to assemble valve guides in aero engines. The valve guide holes are heated by a plug type induction heater, the guides being inserted after freezing to –120° F.
4. Another manufacturer previously assembled a bevel gear on to a spline shaft by using a 50 ton press. Now, by sub-zero temperature treatment of the shaft the gear can be easily fitted over the spline by using a hand operated arbor press.
5. In the tool room of a notable manufacturer of aero and gas turbine engines the usual practice was to press-fit hardened steel bushings or plugs into unhardened fixtures. This type of work is now speedily done by sub-zero treatment of the inserts. A typical example is where a plug 1.001 in. in diameter is shrunk to fit a 1.000 in. hole. Treatment time and temperature is 15 to 30 minutes at –100° F.

other miscellaneous uses

The higher altitude flying of today's aircraft increases the possibility of failure due to the very low temperatures encountered. It is most essential then that the high precision components and

instruments will function satisfactorily at these low temperatures. The use of sub-zero temperature refrigeration plant in the testing of such equipment has made a great contribution to the safety of high flying aircraft, and has also enabled many new discoveries to be made in this direction.

storage of aluminium rivets

Aluminium rivets, as is well known, will gradually lose ductility and harden if held at room temperature after annealing. To retain such ductility they are therefore stored at a temperature of 32° F. Such rivets will remain soft enough for working for about 36 hours. However, if stored at –50° F they will remain ductile for about a fortnight.

machining of rubber

Rubber parts can quite easily be machined, drilled and reamed to precision tolerances if frozen at temperatures of –70° F.

removal of optical lenses retained with pitch

The former removal of optical lenses from grinding blocks, to which they are retained by pitch, was by thermal means, this resulting in scratches and breakages of a large proportion. Also, it was a dirty and messy job. Manufacturers have found that by submitting the lenses to temperatures of between –40°F and –70°F, the pitch readily drops off. Resultant advantages are speedier production and the reclamation of the pitch which was formerly wasted.

improving magnetic qualities of steel

A well-known speedometer manufacturing company advises that only by sub-zero treatment could satisfactory magnetic properties be obtained. The magnets were submitted to a temperature of –120° F for a period of four hours and afterwards given a draw of 300° F for one hour. After being magnetised the parts exhibited greatly improved properties.

dehydration of gases

Hydrogen and helium for aircraft use are dehydrated quite easily and speedily at temperatures as low as –150° F. Drying is done by piping the gases through copper coils which are immersed in a convection fluid filling the chilling chamber.

investment castings

A more recent development in the use of sub-zero temperature application is used in the production of investment castings, where mercury is utilised as a forming agent. In this method mercury is poured into a die, the whole then being refrigerated to solidify the mercury. The solid mercury form is then removed from the die and coated with a special type quick-hardening slurry. After the mercury has regained its molten state it is run out, leaving an accurate formed mould which is further processed prior to being filled with molten metal. Casting produced by this method can be made to precision tolerances and finish ; also no loss of mercury is incurred.

Thus, as will be seen, there are numerous applications and possibilities for sub-zero temperature refrigeration, the further development of which now remains with enterprising industries.

AN ANALYSIS OF MATERIALS AND PLANT IN CURRENT USE IN THE FURNITURE INDUSTRY —

continued from page 197

(vii) *pullover*

The drying action of the lacquer inevitably leaves some effect of "orange peel". In order to obtain the smooth, full finish required, a pad consisting of cotton wool covered by linen and soaked with a solvent is applied by hand to the finished surface. The action of the solvent causes the top film of the lacquer to soften and the manual movement of the pad eliminates the microscopic "craters" which cause the orange peel effect.

safety precautions

Cellulose materials are, of course, highly inflammable and dangerous, and strict enforcement of Factory Act regulations is essential for the adequate safety of those employed in a cellulose area. The requirements of these regulations include fireproof floors, walls, ceilings, and the flameproofing of lighting, switches, motors, and all other electrical equipment.

The initial capital cost and subsequent maintenance of such equipment is therefore very much higher than would be required for a spraying department employing high flash point materials.

The cellulose suppliers are very mindful of this fact and have for several years been endeavouring to develop a suitable material which would eliminate the need for such elaborate precautions. They are gradually reaching a stage — particularly with synthetic resins — where some degree of success is being achieved and which will ultimately be of benefit not only to the manufacturer but also to the consumer, since the indications are that such material, when perfected, will have a greater surface strength and better adhesion than the normal cellulose material.

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EXTRACTS FROM

REGION AND SECTION REPORTS

Presented to Council, 29th January, 1959

EAST & WEST RIDINGS REGION

Doncaster

The Section started the Lecture Session with the Regional Meeting, which was followed by a small dinner party. The lecture, which was given by Mr. E. Hughes of Leicester, was very well attended and appreciated.

The Section has since held two other lectures; the first, on "Spark Machining" by Mr. G. H. C. Rhodes, and the second, which was a joint meeting with the Doncaster Engineering Society, on "Ball and Roller Bearings", when the speaker was Mr. C. S. Clark.

Halifax and Huddersfield

Mr. H. W. Bowen (Chairman of Council) and Mr. F. W. Cooper (Education and Technical Officer) came to Halifax on 3rd November, at the invitation of the Committee. There was a very frank discussion and exchange of views on the Institution's general and education policies.

It was felt generally by the Committee that more meetings of this nature should be held. Much useful information could be exchanged.

The Committee intend to discuss the implications of the new membership examinations at their next meeting.

Halifax and Huddersfield Graduate

The Session's programme has begun quite successfully with, for the first time, a combined lecture and visit at John Mackintosh Limited, which proved to be very well attended and interesting.

The Committee is actively considering the various possibilities of stimulating recruitment to the Graduate Section.

Sheffield

Members of the Materials Handling Group held another meeting in November, at which several visitors were present.

The Section's Representative on the Materials Handling Committee, Mr. H. Steel, outlined the objects of the Group, and gave a resumé of its activities up to date, after which there followed a general discussion.

A list of suitable films and books on Materials Handling is to be prepared and circulated to interested members, and a practical demonstration of handling problems in a modern 11 in. mill was arranged for 26th January, 1959.

EASTERN REGION

Ipswich & Colchester

The Section lecture programme commenced at Colchester in October, with an extremely interesting Paper on "Building Merchant Ships in a Modern Shipyard", by Mr. J. Leather, A.M.I.N.A. This was a joint meeting with The Colchester Engineering Society.

The November meeting was held in Ipswich, again jointly, this time with the Eastern Counties branch of the Institute of Welding. The Paper covered the technique of "Joining Dissimilar Metals" and was fully presented by Mr. A. A. Smith, B.Sc., A.I.M., A.M.Inst.W., and Mr. J. G. Young, B.Sc., A.M.Inst.W.

During June, 1958, Head Office circulated to the effect that the Finance and General Purposes Committee had, after careful consideration, decided that the issuing of printed programme booklets should be discontinued. The Section Committee did not altogether agree with this move, and it was arranged to circulate to all members in this Section, an inexpensive duplicated leaflet giving the lecture programme details. It was felt that all members should have this information well in advance, thus assisting to maintain the good lecture meeting attendance which is obtained from a scattered membership.

The Section Committee has been giving consideration to the possibility of inviting two junior members to attend its monthly Committee meetings, this having been decided as a means of enabling the junior members to play a more active part in the affairs of the Section. To assist the election of their two representatives, it is proposed, after much discussion and with Head Office guidance, to arrange a semi-social evening for junior members of the Section, with the Committee in attendance, during March, 1959. The Education Officer, Mr. Cooper, kindly consented to address the junior members on this occasion.

Norwich

The first lecture meeting for the 1958-59 Session was held on 10th September, when an interesting Paper was given entitled "Material Control, Progress, Machine Loading".

The Lecture of 22nd October, entitled "Die Casting—how else would you make it?" was given by Mr. A. Chivers, and was much enjoyed by those present.

MIDLANDS REGION

At Wolverhampton on Wednesday, 10th December, 1958, over 500 members and visitors heard Herr. L. Schuler deliver his Paper "Reduction of Costs through use of Transfer Presses", and the showing of a short film illustrting the uses of these machines.

The Region is again indebted to the Principal of Wolverhampton and Staffordshire College of Technology, Dr. Scott, for the facilities made available to the Institution.

The Chairman entertained the speaker to an informal supper party, thus rounding off a most successful occasion.

In April, Birmingham will be the venue of the Regional Dinner, and the Region looks forward to receiving the President, The Earl of Halsbury, and the chief guest, The Rt. Hon. Gerald Nabarro, M.P.

Arrangements are also well in hand for the One-Day Conference, on "Measuring Tomorrow's Production", when Papers on modern measuring techniques will be given at the works of The Coventry Gauge and Tool Co. Ltd., Coventry.

Birmingham Graduate

The Section's activities over the first part of the 1958-59 Session have been very successful, and attendances at both Lectures and Works' visits have been up to average. The final item to be held this year was the film show on 9th December, to which ladies were invited.

The Section is shortly to hear a Paper entitled "The Construction and Development of Guided Missiles". In view of the changes in defence from air attack, this Paper is expected to draw a large attendance.

Coventry Section

The first half of the 1958-59 Session having been completed, it can be reported that the attendance at lectures, although not quite up to the high average of the last session, gives cause for satisfaction. The first lectures were all well received and lively discussions followed in each case.

Once again the Annual Dinner and Dance, held at the Masonic Hall on 17th October, proved very successful. Due to the unavoidable absence of the Section Chairman, Mr. Oubridge, the chair was taken by Sir Stanley Harley. The function was honoured by the presence of The Lord Mayor and Lady Mayoress of Coventry; also present were many industrialists, including Mr. J. Wright, Chairman of the Coventry Chamber of Commerce, who proposed the toast of the visitors.

Coventry Graduate

Full support this Session has warranted the rather heavy programme arranged, and following a very successful start, the Section's activities continued with a visit to a canning factory. This was a social visit and was enjoyed by members' wives just as much as by the members themselves.

A "Production Panel" was held early in October but met with a disappointing response. This was more than made up for, however, by a full day visit to Messrs. Timken of Duston. The visit was extremely well organised and was of absorbing interest since bearing manufacture has, until recently, been the subject of close security. Further interest in this visit was aroused since a comparison could be made between the old factory and the methods employed in the automatic factory.

A lecture on the versatility of modern machine tools held in November was extremely well attended and presented. Again in November, a social visit was organised to the Belgrade Theatre, Coventry. This proved so overwhelmingly successful that a future visit is to be arranged. An insight into the techniques of play production was of great interest, particularly since this is the only new theatre to be opened for many years in the whole country, and incorporates many new ideas backstage.

Early in December a lecture on "Production Techniques on the A.W.A. Argosy Freighter Coach Aircraft" was given to an extremely large audience. The film presented to the meeting had been especially made, and the Coventry Section is gratified to be the first to which it was given. It is understood that other Sections have already asked for his lecture to be given to them.

Shrewsbury

Section activities for the first half of 1958-59 Session have comprised three lectures. These have been generally successful and well attended; the November lecture, however, was a fog victim.

Another successful Dinner-Dance was held on Friday, 14th November, at which the Section were pleased to welcome, among others, Mr. A. G. B. Owen, C.B.E. (Chairman of the Owen Organisation), Mr. H. W. Bowen, O.B.E. (Chairman of Council) and Mr. H. Tomlinson (Midland Regional Chairman).

Wolverhampton

The outstanding event of the past quarter was the Midlands Regional meeting at the Wolverhampton and Staffordshire College of Technology on Wednesday, 10th December, 1958.

A Paper entitled "Transfer Presses" was presented by Herr. L. Schuler, of the company in Germany bearing his name. Great enthusiasm was shown for the meeting and an audience of over 500 was present. Even in an area where a wide variety of press work is carried on, the subject appeared to be somewhat novel and fortunately, it was admirably supported by a film and slides. A lively discussion ensued but linguistic difficulties were hard to avoid.

The Wolverhampton Committee are looking forward to a visit by the Chairman of Council, Mr. H. W. Bowen, O.B.E., at one of their meetings early in the New Year.

Wolverhampton Graduate

The Section's annual social occasion was the Christmas Dinner-Dance which was held this year at the Mount Hotel, Tettenhall, Wolverhampton, on Saturday, 20th December.

Many requests have been made for a lecture having a simple and elementary approach to the problem of electronic machine tool control. Accordingly Mr. M. G. Page, who is head of the Production Engineering and Management Department at the Wolverhampton College of Technology, has agreed to give such a talk in February next. He is entitling his talk "The A.B.C. of Machine Tool Control", and is aiming it at graduates and college students who have little or no electrical background. It is anticipated that considerable local interest will be aroused by this lecture, due in no small degree to the popularity of the speaker.

In March, activities will be entering fields new to the Section. The Annual General Meeting will be followed by a film show, in place of the usual lecture. This is being done in order that senior Graduate Committee members will be freed from their obligations in entertaining the speaker prior to his lecture, and so enabled to give their full attention to the Annual General Meeting. In the same month another idea new to the present Committee is being given a trial. A combined visit and lecture to Fischer Bearings Ltd., of Wolverhampton, has been arranged. Members will hear a talk on special production techniques used in the manufacture of ball-bearings, and these techniques will then be seen and demonstrated during the following tour of the factory.

Worcester

The arranged programme is proceeding and is well received by an increasing audience, the extra lectures at Redditch being very well supported.

Mr. F. W. Cooper (Education Officer) visited the area in November and advised the Committee on the effect of the 1960 A.M. Examination requirements.

NORTHERN REGION

Newcastle upon Tyne

Meetings during the present Session have been very well attended. The November meeting was a joint meeting with the Institution of Mechanical Engineers, when Dr. H. Barrell presented his 1957 Sir Alfred Herbert Paper, "The Bases of Measurement".

The Section's members have strong feelings regarding the decision of the Finance and General Purposes Committee to discontinue the printing of Programme Booklets. In order that a Programme Booklet should be available for the current Session, the Chairman arranged for the printing of a Section Programme, but it cannot be anticipated that this will become a practice.

The matter has been taken up with Headquarters requesting the matter be reconsidered and a negative reply has been received. It is suggested the matter be reviewed again prior to the commencement of the next Session.

Newcastle upon Tyne Graduate

During the past quarter the Section has visited three local works. These visits, which were most enjoyable and successful, were better attended than in the previous Session.

The Committee hope that continued and increased interest will be shown by all members of the Section for the remainder of the programme.

The Section has visited Newcastle Breweries Ltd., at Newcastle; The North Eastern Marine Engineering Co. Ltd., at Wallsend; and Churchill Gear Machines Ltd., at Blaydon.

This last visit was arranged at very short notice and was to see a special automatic line for the manufacture of layshaft gears for the automobile industry; a unique product in this area.

Tees-side

Two successful lectures and meetings have been held during the past quarter.

The Committee members are pleased with the numbers and quality of new applicants.

Arrangements for the President's visit in January are now complete.

NORTHERN IRELAND REGION

Winter activities commenced early in September, when, at the kind invitation of Short Bros. & Harland Ltd., a party of members visited their Queen's Island works, and were conducted through the machine shops, and assembly bays. In the latter a number of "Britannia" aircraft were observed under construction, the main stages of assembly being readily apparent.

Considerable interest was shown by the party in a demonstration of "tape controlled milling" using a vertical milling machine equipped with the E.M.I. system of tape control. Members of the staff had gone to a great deal of trouble in selecting examples of the type of work undertaken, and their collation into an impressive and interesting display. The Section's thanks are due to the Company and those members of the staff who made the visit such a success.

The evening lecture programme began on 16th October, when Mr. J. D. Harper, B.A., gave a talk on "Recent Development in Production of High Duty and Processed Castings". The small but attentive audience were well rewarded by a very comprehensive, competent and well delivered lecture, followed by an enthusiastic discussion.

The programme continued on 20th November with a lecture entitled "The Practical Approach to Management Accounting" given by Mr. W. Murray, M.A., B.Comm., C.A.

An invitation was issued to the local section of the Institute of Cost and Works Accountants for this meeting.

To a capacity audience Mr. Murray gave a brilliant survey of the fundamental factors involved in developing a practical means of collecting and presenting efficient cost control information to management. Following the lecture a very lively discussion ensued to the close of a highly successful and worthwhile evening.

The first lecture for 1958, on 11th December, was given by Mr. E. W. Hughes, M.A., B.Sc., on "The Background to Incentives and Industrial Motivation".

Mr. Hughes, who is the Organiser of Educational Research at Leicester University, proceeded in masterly fashion to analyse human behaviour and motives in relation to the industrial scene. From the manner and length of discussion that followed, this was undoubtedly an outstanding lecture.

NORTH MIDLANDS REGION

Since the last report there has been a change in the constitution of the North Midlands Regional Committee. The following new members are cordially welcomed: Messrs. R. M. Evans, J. V. Gutteridge, K. Liquorish, J. Cunningham, M.B.E., J. Smedley, E. J. Baseley, J. Lowther, L. P. Simpson and A. Heiser.

Under Regional organisation this Committee has, in the past, functioned admirably, and there is every indication there will be even closer co-operation between the Sections in the future. Mr. A. S. Johnstone has been elected North Midlands Region Representative on the *Ad Hoc* Committee on Organisation.

The Region is indebted to the Nottingham Section for their offer to organise the now traditional One-Day Conference in 1959. This Conference will be held on 6th June, and the event promises to maintain the high standard set on previous occasions.

Lincoln

During the period under review, this Section has held two lecture meetings and the Annual Dinner-Dance.

The first lecture meeting was held at the Ruston Club, Lincoln, on Thursday, 23rd October, when Mr. A. Clark gave a talk on "Plastics Material in Engineering". This was well received and was followed by a very lively and interesting discussion.

The second lecture meeting was held at the same place and Mr. R. J. Cowie, of PERA, gave a talk on "Some Factors Affecting Cutting Tool Performance". This was an excellent lecture and was very interesting during the discussion period.

The Annual Dinner-Dance was held at the Saracen's Head Hotel, Lincoln, on Friday, 7th November. With the help received from London office this proved to be a most successful evening.

Loughborough Student Centre

On 5th November a party of 24 visited PERA, Melton Mowbray; and on 25th November the Section heard a lecture by Mr. J. H. Osborn on "A Modern Foundry for the Manufacture of Small Steel Castings by New Moulding Techniques". This lecture was well illustrated and there was a good selection of exhibits.

Nottingham

The Section have now completed the first half of the Section lecture programme, and are very pleased to report that attendance at the lecture meetings has been maintained, a number of visitors being present on all occasions. The Papers given have been of a very high standard and of great interest, particularly a Paper entitled "Moulding Processes for Thermoplastic Materials" by Mr. L. W. Turner, which provoked a most interesting and instructive discussion.

The Section were privileged to hear an enjoyable lecture on 3rd December by Mr. E. Martin Webb, who spoke about production control by computer, outlining his talk by reference to an actual factory layout.

At a meeting held on 15th October, 1958, the Section Committee had the honour of a visit from the Chairman of Council, Mr. H. W. Bowen, O.B.E. After being introduced by Mr. B. A. Green (Section Chairman) to Committee members, Mr. Bowen joined in the business discussion, and offered suggestions and advice on many matters, his contribution to the meeting being most helpful and enlightening.

Arrangements are now in hand for the North Midlands Regional One-Day Conference, which is to be held on Saturday, 6th June, 1959, at Nottingham, the subject being "Communicating in Industry". Joint Conference Secretaries have been appointed and a provisional programme has been agreed upon, this taking the form of morning visits for members and ladies, lunch, afternoon visit for ladies and the Conference in the afternoon for members, followed by The Dansant.

NORTH WESTERN REGION

It was noted with satisfaction that the attendances in all Sections were well above average for the first period of the lecture programmes, with the average attendances at 100 members and visitors.

Mr. R. S. Clark, the Region Honorary Treasurer, has been nominated as the Regional Representative on the *Ad Hoc* Committee on Organisation.

The Regional Lecture, 1959, is entitled "Problems of Productivity in the Cotton Textile Industry" and will be given on 27th April, 1959, by Mr. Allan Ormerod, A.M.I.Prod.E.

Liverpool

The Liverpool Section Committee, in their endeavour to provide up-to-date technical information, decided on a series of lecture meetings to study some of the subjects which are being added to Parts II and III of the 1960 Associate Membership Examination structure.

Mr. F. W. Cooper (Education and Technical Officer) visited Liverpool in October to explain all the implications involved. This meeting was well attended by the various Principals and Heads of Technical Departments of the various colleges.

In November, the first of the subjects "Management of Men" was studied. The Committee had invited Dr. Kent, J.P., a prominent Warrington industrialist, to speak on this subject but, unfortunately, Dr. Kent was unable to give his Paper due to illness. The Section are indebted to him for arranging for Mr. Hall, B.Sc., to deputise for him. Mr. Hall did full justice to the excellent material that Dr. Kent had prepared and a lively discussion followed (see pages 181-188 of this Journal).

For the December meeting the Committee invited Mr. A. G. Hayek, Chairman of the Materials Handling Group, to speak in Liverpool on the subject "Materials Handling — A Challenge to British Industry", and the Section are indebted to the Liverpool and District Scientific, Industrial and Research Library Advisory Council for offering facilities for staging this meeting in conjunction with them, at the Central Libraries, Picton Road, Liverpool. These joint meetings, arranged by the Advisory Council with the various professional institutions on Merseyside, do offer an opportunity once a month for anybody to take advantage of hearing lectures given by some of the best brains in the country on a variety of subjects. The Committee strongly recommend members to take advantage of these services, also the facilities that the splendid technical library can offer to industry.

Liverpool Graduate

The November meeting, at which a lecture entitled "Servo Mechanisms" was presented to the Section by Mr. Pomfritt, a member of the staff of Liverpool College of Technology, proved most successful. This was followed on 9th November by a works visit to Kelvinator Ltd., where a party of members and guests toured the production shops and saw the manufacture of domestic refrigerators.

Manchester Section

The first half of the lecture progremme for 1958 - 1959 is now completed.

The October Paper, "Zeta", was presented by Mr. J. Blears and the Manchester Section are pleased to have initiated this new lecture. The November Paper, "Diploma in Technology", was presented by Dr. C. Whitworth, Principal of the Royal Technical College, Salford. Because of a poor attendance due to bad weather, the Manchester Section Syllabus Committee are to present the Paper again in the 1959 - 1960 programme.

The Manchester Section Materials Utilisation Group has been disbanded, after a very successful period of office, under the Chairmanship of Mr. H. Handforth.

The Section Materials Handling Group have organised a course on "Materials Handling in the Cotton Industry", at Oldham Technical College, at the request of the College. A similar request has been forthcoming from the Wigan and District Mining and Technical College, Wigan.

Mr. R. E. Mills, of the Section Committee, gave a Paper on 7th October, 1958, to the Bolton Boys' School Parents' Association on "Production Engineering as a Career".

Manchester Graduate

The first lecture of the present Session was held on Wednesday, 15th October, and was entitled "Copy Turning Techniques". On Saturday, 25th October, a party of members and visitors attended a most interesting visit to A. V. Roe Ltd., Chadderton.

Mr. F. W. Cranmer, the Senior Section Chairman, has once again kindly offered a prize of 3 guineas to be awarded to a Graduate or Student of the Manchester Section who submits the best Paper of 2,000 words written on any subject connected with production engineering. A circular has been posted regarding this and it is hoped for a good response from members.

The Chairman of the Graduate Section, Mr. R. C. Yarnell, has also circulated members with details of the programme arranged for the present Session, and an effort has been made to stimulate further interest by our members in the Section's activities.

Preston

Attendance figures for the first two lectures of the 1958 - 1959 lecture programme show that the upward trend over the past two years has been maintained, but the number of members, as against guests, is still relatively small.

Good attendances were attracted by "A New Approach to Production Control" given by Mr. J. L. Burbidge at the Harris College of Further Education, Preston; and "Work Study as an Aid to Management" given by Mr. C. R. Macnabb at the Municipal Technical College, Blackburn.

Stoke-on-Trent

The lecture programme for the present Session has so far proved most successful. The first lecture, held during October, was presented by Mr. H. G. King, and entitled "An Introduction to Patternmaking in Plastics". An exceptional attendance of 85 was obtained and a most interesting and instructive evening was enjoyed.

In November, a lecture entitled "The Uses of Rubber in Engineering" was given by Dr. A. N. Gent and provided much food for thought for all present and promoted a most lively discussion.

It is regretted that the Chairman, Mr. A. McDonald, has been forced to resign due to his taking up a new position. Mr. McDonald has been a most ardent worker for the Stoke-on-Trent Section and members wish him every success in his new appointment.

Mr. A. G. McKay has been elected a member of the Section Committee.

SCOTLAND REGION

Dundee

The Section is delighted to report increased activity both in membership and attendance at meetings. The increase in membership is due to the interest and work done in the Technical College, culminating in the award of Higher National Certificates.

The attendance at meetings this year has risen to an average of 60 and this is due to careful selection of subjects with special interest for the area. The joint meeting with other institutions on the subject "Operational Research" brought out an attendance of about 100 on a cold, raw winter's night.

The Section's own meetings: "Problems Associated with Spark Erosion" by Mr. W. Ullman, of Locarno; "Copy Turning" by G. T. Helps, of Nottingham; and "Powder Metallurgy" by Mr. G. R. Bell, of London, were all well received, judging by the interest shown and the questions asked.

The Committee are extremely indebted to the speakers for giving their valuable time and travelling these long distances to give up-to-date information on new materials and methods.

The Education Officer, Mr. F. W. Cooper, and Registrar, Miss K. Allan, paid a two-day visit to the Section in connection with the syllabus for the Institution's new educational requirements. This visit by Headquarters' staff to a Section was beneficial both to them and to the Committee.

SOUTHERN REGION

Oxford

The 1958 - 1959 Session of the Oxford Section commenced with meetings at Banbury on 23rd September, and in Oxford on 21st October and 18th November.

These three meetings were all within the scope of the Section theme for the year, i.e., "The Impact of European Free Trade on British Industry", and the meetings were concerned firstly with generation and distribution of electricity; secondly with oil; and thirdly with motor cars.

All meetings were extremely well attended and proved of topical and popular interest.

Reading

The Section had the great honour and pleasure of having the President, Lord Halsbury, present his Paper, "Technology and Humanism", at the first Regional meeting to be held in Reading on 18th September, 1958. The evening was highly successful and an attendance of approximately 90 included the Mayor of Reading, who officially opened the proceedings.

In another vein, however, the Committee have viewed with some disquiet the somewhat parochial decision to cancel the issuing of the current lecture programmes to members without seeking the opinions of all Section Committees. This item of expense was already covered in Section budgets.

SOUTH EASTERN REGION

On 28th November, about 340 members of the South Eastern Region and their guests were present at the Region's Annual Dinner and Dance at the Savoy Hotel. The principal guest was the Chairman of Council, Mr. H. W. Bowen, O.B.E., who was accompanied by Mrs. Bowen.

At the above function a presentation was made to Mr. H. S. Woodgate, the winner of the 1957 - 1958 Graduate Prize Competition organised by the South Eastern Region.

London

This is the last quarterly report for the year 1958 and partly covers a period when Section activities had slowed down. However, the lecture programme started in October and is now in full swing.

There have been two lectures held at the Royal Commonwealth Society, one at Brighton and one at Croydon. One particularly interesting lecture was that on "Human and Organisation Problems in Inspection Departments". Attendance, however, was disappointing, but this was perhaps due to widespread fog.

Arrangements are now in hand concerning the London Section Dinner in February, 1959, and it is hoped that this function will prove as enjoyable as it has in previous years.

Luton

During the last quarter the Section's winter programme started very well with two very interesting lectures. The first, in October, entitled "The Deficiences of the Engineer-Manager", was given by Mr. J. L. Gwyther, B.Sc. (present Chairman of the Section).

In November, the annual joint meeting with the Euston Branch of The Institution of Mechanical Engineers was held in Luton. Mr. Norman Stubbs, M.B.E., B.Sc.(Hons.), gave an entertaining resumé of "Machine Tool Development in the U.S.S.R.", based upon his recent tour of the Soviet Union.

The Committee, together with the Graduate Section Committee, had a very interesting meeting during November with Mr. F. W. Cooper, Education Officer of the Institution. It is hoped that following this meeting increased knowledge of the purpose of the Institution will be spread, via works training officers and technical colleges, to students and apprentices in the area.

The Committee has maintained constant contact with the Luton and District Productivity Committee and with the South Eastern Regional Committee.

Luton Graduate

The Luton Graduate Committee wish to extend their sincere thanks to Mr. F. W. Cooper for his help and co-operation when he attended the joint meeting with the Senior Committee. This meeting resulted from a proposal put forward by the Graduate Committee, that there was a need for promoting the interest in production engineering of young trainee engineers in the area in qualifying by means of the syllabus set out by the Institution. As a result of this meeting, Mr. Cooper has kindly promised to spend some time visiting personnel and training officers in this area, to discuss with them the desirability of apprentices of high ability undertaking training leading to qualifications in production engineering.

The visits and lectures this Session have had much success, all being well attended and thoroughly enjoyed. The subjects of these activities have ranged from computers to conveyors, from plastics to railway workshop modernisation, on to visiting the motorway being built locally. This London-Yorkshire motorway visit was very successful, the coach being well over-subscribed and late applications having to be turned away. The visit began in the News Room at Newport Pagnell, where typical models, plans, schedules, photographs and other information were on display. Here there was a most informative talk from the Chief Civil Engineer in charge of the whole project, before the party moved off on a tour of several miles to see various parts of the motorway under construction. The Section were invited to see it again in April or May, and intend to repeat this successful venture.

As a result of the lecture on "Railway Modernisation", given by a member of the Work Study Department of the Derby Depot Workshops, it is hoped to arrange a visit to these Workshops for the next Session, and also to arrange another lecture on a further aspect of their modernisation programme.

The Section are now looking forward to the visit arranged for January, which will be to the local General Motor Car firm on an all-day visit. This should prove another highlight of the current Session.

South Essex

The 1958 - 1959 winter Session opened with a meeting held at the Mid-Essex Technical College, Chelmsford, on 8th October. Mr. Norman Stubbs, M.B.E., B.Sc.(Hons.), the Editor of *Metalworking Production*, with the aid of slides, picture boards and his first-hand knowledge, obtained from his visit to Russia, spoke on "Russia's Approach to the Production of Machine Tools and Associated Equipment".

The second meeting was held at the Ilford Club, Ilford, on 12th November. A Paper on "The Application of Radio-active Isotopes in Industry" was presented with the aid of slides by Mr. J. L. Putman, of the Isotope Division, Atomic Energy Research Establishment, Harwell.

The third meeting, held in Chelmsford at the Social Centre of The Hoffman Manufacturing Co. Ltd. on 10th December, heard a Paper on "Ergonomics in Industry" presented with the aid of lantern slides by Dr. W. F. Floyd, Senior Lecturer in Physiology, Middlesex Hospital, University of London.

The next meeting will be held on 11th February, 1959, at the Southend-on-Sea Municipal Technical College. The title of the Paper is "Epoxy Resins".

SOUTH WESTERN REGION

Cornwall

In October, the winter programme commenced with a visit by Mr. C. W. J. Crawford, A.I.M., Technical Secretary of the Steelmaking Division of the British Iron and Steel Research Association. Mr. Crawford presented an extremely sound Paper entitled "Some Current Developments in the Steel Industry".

This was a joint meeting with The Institution of Mechanical Engineers and the Cornish Institute of Engineers. During the discussion that followed it was very interesting indeed to hear of another's appreciation after one's own opinion had been formed. The questions from members were clearly grouped and a meeting of engineers on a common subject is to be recommended, when the engineers perform different functions in industry.

"The Mechanical Design of an Experimental Plant-type Gas Turbine" was the title of a Paper presented by Mr. L. T. Whitehead, A.M.I.Mech.E., in November. In 1956, Mr. Whitehead joined the Engine Research Branch at the Ministry of Supply (Air) Headquarters, where he is responsible for mechanical engineering and materials. This subject proved to be of much interest and a long discussion followed.

Gloucester

The Section has held two lectures, one on 25th September, when Lord Halsbury gave a lecture on "Technology and Humanism" to an audience of 300; and a second on 6th October, when Mr. A. L. Thorogood gave a lecture outlining the work and scope of the D.S.I.R.

The lecture was illustrated by some very good slides showing experimental work in progress at the various research stations.

Western

The joint lecture with the Royal Aeronautical Society was up to the usual standard and attracted quite a reasonable audience. The subject had a considerable leaning to the aircraft industry but, nevertheless, was interesting.

The Annual Dinner and Dance was again very successful and the Section were delighted to have the President, Lord Halsbury, as principal guest. They were also very pleased that Mr. and Mrs. Woodford were able to visit them again this year.

WALES REGION

The Regional Committee have now changed the venue of their meetings from Bridgend to Aberdare in order to ease transport problems. It is hoped that this will encourage an increase in attendance at Regional meetings.

It has not been possible to hold a joint lecture meeting in both Swansea and Cardiff this Session, but lecture programmes for 1959 - 1960 will be so arranged to enable this to be accomplished. The Committee feel that it would provide a medium for members of the Cardiff and Swansea Sections to discuss problems of mutual interest to the two Sections.

Arrangements are being finalised for the annual Regional works visit and members will be notified in good time in order that they may attend.

Mr. W. H. Bowman, the former Chairman, has accepted the Committee's invitation to represent the Wales Region on the *Ad Hoc* Committee on Organisation.

It has been agreed to invite Committee members of both Sections to attend the next Regional meeting, when the annual Regional Dinner will follow the Committee meeting. This provides a good opportunity for an interchange of information between the respective Committees.

Cardiff

The lecture programme has got off to a good start and attendance at a joint lecture with the Institute of Cost and Works Accountants and the British Institute of Management was particularly good.

The Section have also been honoured by a visit from the Chairman of Council, Mr. H. W. Bowen, O.B.E., who gave a very interesting discourse entitled "The Institution". This is the first occasion on which the Section has had an opportunity of meeting an executive member of Council.

The Committee are doing all in their power to provide lectures of interest to members and are spending many of their leisure hours in the interests of members; their efforts deserve a greater measure of support than they are getting at the moment. They have, however, achieved some success with younger members. Increasing numbers are turning to production engineering and are seeking enrolment as Graduates and Students. If this trend continues the long-cherished hope of a Graduate Section in the Cardiff Section may become a reality.

There are three more lectures to complete the lecture programme for 1958 - 1959 and it is hoped that members will give maximum support to the Committee by their attendance.

Swansea

The 1958 - 1959 lecture programme of the Section is making excellent progress, and already three most interesting lectures have taken place at the Central Library, Swansea, before large and appreciative audiences.

The Swansea Education Authority have recently formed an Advisory Committee on the teaching of Mechanical and Production Engineering within the area, and have invited the Swansea Section of the Institution to nominate a representative on this Committee. Mr. Hopkinson, Section Chairman, was unanimously elected for this office.

The Committee have also been active during the summer recess in making strenuous representations to the Director of Education, Swansea, in an endeavour to improve the undeniably poor conditions now prevailing at their Technical College for the high level teaching of Mechanical, Production and Automobile Engineering. These representations are a direct follow-up to the important work already done in that field by Mr. F. W. Cooper, Education Officer of the Institution. The Committee feel that owing to the necessity of attracting new light industries to Wales, this matter is of the utmost priority.

SECTIONS OUTSIDE THE UNITED KINGDOM

Adelaide

At the September General Meeting the concluding lecture of a series was given by Mr. A. Stacey, the title being "Distribution and Sales". This series proved to be interesting and attracted an average attendance of 40 members and visitors.

The Annual General Meeting, held on 29th October, was well attended. At the conclusion of the official business an interesting talk was given by Mr. I. B. Wall, a Research Engineer from Philips Electrical Industries Pty. Ltd. His subject was "Bringing TV to Your Home". After outlining the principles, Mr. Wall explained some of the difficulties confronting TV engineers in Australia. An interesting aspect of the talk was the sociological impact it would have on home life.

The James N. Kirby Paper, read by Professor Marcus L. Oliphant, F.R.S., on 4th November, was the highlight of the Section's activities for 1958 and represented the culmination of nine months of planning and preparation by members of the Committee. This was the Section's first attempt at organising such a function, and the attendance of approximately 800 was most gratifying (see pages 165 - 170 of this Journal).

The year's programme concluded on 26th November with a visit to the Actil Cotton Mills, where about 30 members and friends witnessed the manufacture of cotton goods from the raw material to the finished product.

Bombay

The activities of the Section were maintained in a quite successful manner during the period under review.

A film show on "Designing and Applying Carbide Tools" was held in October, 1958. This proved to be most successful and more than 150 guests and members were present.

Also in October there was a visit to the works of Zenith Tin Works Private Ltd., who had recently moved to its new premises and completely changed its plant layout.

At the first Committee meeting for this period a panel of judges were selected for deciding the best Paper for the Wild-Barfield Award for 1958. It was further agreed to have copies of the Institution's publications which would form the nucleus of a library in production engineering subjects which the Section intends to maintain.

In November, a very interesting Paper on "Productivity Technique and its Application in Indian Industries" was delivered by Mr. T. M. Jacob, Technical Advisor to the Government of India and Honorary Secretary to the Bombay Productivity Council.

In November, the Honorary Secretary informed the Section Committee that the National Productivity Council is going to send about 10 Productivity Teams to visit Western European countries, U.S.A. or Japan, and the Section has been requested to nominate 10 members for possible inclusion in each of the following Study Teams:

1. Preventative Maintenance.
2. Materials Handling.
3. Plant Layout and Factory Construction.

The Section Committee has selected 10 names and forwarded these to the National Productivity Council.

The Indian Standards Institution (Bombay Branch) have co-opted Mr. Pal, the Secretary in their Executive Committee of the Bombay Advisory Committee for the I.S.I. Branch. Mr. Pal will represent the Institution.

In December, a Paper entitled "Powder Metallurgy and its Application in Engineering Industry" was delivered by UNESCO Professor E. I. Mozjukhin, of the Indian Institute of Technology, Bombay. Also a visit has been arranged at the works of Messrs. Guest, Keen, Williams Ltd., and possibly a visit to the works of Messrs. Sankey Electrical Stampings Ltd. on the same day, as both the works are situated in the same locality and members would find it much more interesting to have a combined visit to both the works.

The last Committee meeting for this period will be held on 30th December. The formation of an Indian Sub-Council of the Institution, combining both Bombay and Calcutta Sections is to be discussed.

Mr. Goodchild, of Calcutta Section, has had discussions on the above question with the Chairman and the Secretary. He gave an account of the talk he had with members of the Council at London and explained that they would, he thought, take a very favourable view of the proposition and would be prepared to help to their utmost. The Council in London is only waiting for concrete suggestions from

members in India. Mr. Shah, the Chairman, accepted the suggestions of Mr. Goodchild subject to the Section Committee's confirmation and he is going to contact Mr. T. R. Gupta, Chairman of Calcutta Section, in this connection.

Calcutta

There have been no Section meetings during this quarter due mainly to the inability of the speakers to appear on schedule. However, two lectures have been arranged for January and February, and it is hoped that 1959 will be a success as far as such activities are concerned.

There has been a lot of activity behind the scenes and the Section Committee has been extremely busy.

The Honorary Secretary represented the Section at the Indian Standards Convention in New Delhi. Investigations for expanding the activities of the Section have made very good progress and Mr. Goodchild and the Honorary Secretary recently had discussions with the Director of the National Productivity Council in New Delhi.

It is hoped that the library will be in full use during the coming quarter and it is anticipated that Graduates and Students will take full advantage of it.

Canada

The Section Committee are meeting regularly and are taking concrete steps to reactivate the Section. Apart from the regular meeting business, the following highlights are submitted.

Mr. S. Carroll reported to the Committee on his meeting in London with Mr. Woodford and proved the benefit of this direct contact in being able to bring us up-to-date on the petition for Charter. It was decided to establish a representative for the Committee in Montreal and Vancouver, these being the major membership concentration centres outside of Southern Ontario. To determine the reaction of the membership, it was proposed that a Dinner meeting be arranged, to be held around the end of November.

At a membership meeting on 24th November, 1958, restricted to members only, the response was very encouraging to the Committee, 25 members turning out for the occasion. Following an excellent dinner, the Chairman addressed the meeting, outlining the proposed future activities of the Section. A lively open discussion followed, giving a more intimate feeling to the Section.

The evening was rounded off with a first-class film show, the topics being automation, machine tools and high speed flight (subsonic and transonic). From the tone of this meeting members are most encouraged to continue with the development of the Section.

The membership meeting was reviewed and a Programme Committee set up, under the Vice-Chairman, Mr. S. Carroll. An Education Committee was proposed, in order to meet with the various education bodies in Canada. This Sub-Committee would also be under Mr. Carroll.

The Annual General Meeting was called for 9th March, 1959.

Melbourne

The Melbourne Section has been very active during the last quarter, which has included several highlights to end a successful year.

On 10th September, a special meeting was held at which members met Mr. Harold Burke, Past Chairman of Council, and were pleased to hear the latest news of the Institution.

At the regular meeting on 17th September, Mr. D. W. Griffin, Production Development Engineer of Villiers (Australia) Pty. Ltd., gave a Paper on "The Development of the Villiers Petrol Engine in Australia". This was followed on 19th September by a visit to the Villiers factory at Ballarat, at which members were pleased to see the young but rapidly growing factory.

The Annual Meeting was held on 8th October. Mr. E. J. W. Herbert, Controller of Munitions Supply, was elected Chairman of the Section. Short talks on their recent overseas visits were given by Mr. R. W. Deutsher, Vice-Chairman; Mr. E. Rodeck, a new member of the Committee; and Mr. A. G. Jones, Honorary Secretary.

On 14th November, the Section Annual Dinner was attended by some 180 members and friends, who later heard Dr. H. G. Raggett, C.B.E., Secretary of the Department of National Development, speak on "Mineral Exploration and Development in Australia".

The last item of the year was held on 26th November, when the Productivity Group launched the "Circuit Scheme" in Melbourne. The scheme was described in detail to members of top management in a number of firms, and two circuits, each of seven firms, have been formed. In the work involved, the Institution has received the willing co-operation of the Department of Labour and National Service, which has also studied this British Productivity Council proposal. The Melbourne Section feels that this new activity is most important, and are very encouraged by the excellent response from affiliated firms.

Melbourne Graduate

On 17th September, the Section visited Repco Universal Joints Pty. Ltd. This visit was most interesting, as the most up-to-date techniques and methods are employed by this Company on the production of transmission equipment for the automobile trade.

The Third Annual Meeting was held on 21st October. The office bearers elected for 1959 were: Mr. F. A. Roberts ((Chairman), Mr. K. Stephenson (Secretary), 5 Olinda Street, Glen Waverley, Victoria.

South Africa

On 2nd October, Mr. J. J. M. Roos, General Manager of the Furnace Department of William Smit & Co. (Holland) presented a Paper entitled "Industrial Electrical Furnaces". Mr. Roos was on a short visit to South Africa, and his Paper proved to be most interesting and informative.

On 22nd October, members took part in a visit to the Kelvin Power Station, where an extremely well organised visit was arranged by the staff of the Kelvin Power Station.

On 6th November, Dr. W. Hudson, of the National Institute for Personnel Research, and a well-known educationalist, presented a Paper on "The African in Industry". This Paper was very popular and Dr. Hudson gave some very interesting and progressive ideas on the place of the African in industry today.

On 4th December, 1958, a Social Evening was held at which Mr. H. G. Goyns, a Past President of the Institution, gave a talk on his recent safari trip to the Mountain of the Moon. This meeting was extremely well attended and Mr. Goyns gave a most interesting talk illustrated by sound films and slides, describing a 6,500 mile safari to the lakes and mountains of Central Africa.

After the presentation of Mr. Goyns' talk, films and slides, members adjourned for a very well organised tea. The social aspect of this evening is considered by Council as an extremely important side of the activities of the South African Branch.

As is usual during January, 1959, no general meetings will be held but Council have an extremely full and interesting programme of Papers and visits arranged for the year 1959.

Sydney

The year's lecture programme concluded in October with an address by Professor Bart. J. Bok, Professor of Astronomy, Australian National University, and Director of Mount Stromlo Observatory, Canberra. At this meeting, which opened as the Annual General Meeting, Mr. C. S. Curtis was elected Section Chairman in succession to Mr. S. Downie.

A ballot for the four vacancies on the Section Committee resulted in the re-election of the three retiring members, and the election to the Committee for the first time of Mr. J. W. Fraill, Member.

Mr. J. E. Strick, a past Chairman, and for many years a Committee Member, has resigned from the Committee.

Tribute has been made to Mr. Strick's work for the Sydney Section, and his resignation was accepted with regret.

COUNCIL ELECTIONS, 1959 - 1960

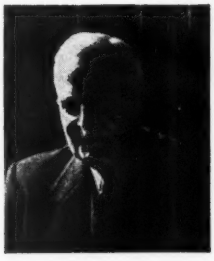
A notice calling for nominations to fill nine vacancies on Council, for the year commencing 1st July, 1959, will be published in May.

The vacancies will be for eight Members and one Associate Member. All Members and Associate Members of the Institution are eligible for election. Before nominating candidates for election, their consent must be obtained.

Candidates for election must be nominated in writing by three Corporate Members of the Institution (Corporate Members : Honorary Members, Members and Associate Members). In addition, each Section Committee may nominate *one* candidate.

PAST PRESIDENTS' NEW APPOINTMENTS

Following the merger of The British Tabulating Machine Co. Ltd. and Powers - Samas Accounting Machines Ltd., **Sir Cecil Weir,** K.C.M.G., K.B.E., D.L., M.C., has been appointed Chairman of the newly - formed Company, International Computers & Tabulators Ltd. Sir Cecil, who had been Chairman of B.T.M. since 1951, was President of the Institution from 1952 - 1953, and last year presented The 1958 Sir Alfred Herbert Paper.



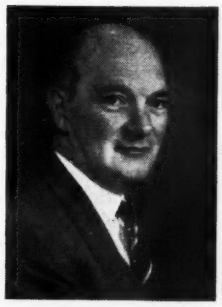
Also on the board of the new Company is **Sir Walter Puckey,** formerly a Director of B.T.M. Ltd. Sir Walter was President of the Institution from 1953 - 1955.

PRESIDENTIAL VISIT TO IRELAND

During a recent visit to the Northern Ireland Section of the Institution, Lord Halsbury visited the Castlereagh factory of International Computers and Tabulators Ltd. The picture shows the President in the apprentice department of the factory. (Left to right) : Mr. W. F. S. Woodford, Secretary of the Institution; Lord Halsbury; Mr. J. Carvill, of I.C.T.; and A. Annan, an I.C.T. apprentice.

LORD HALSBURY LEAVES N.R.D.C.

The President of the Institution, **The Rt. Hon. the Earl of Halsbury,** F.R.I.C., F.Inst.P., has now relinquished his appointment as Managing Director of The National Research Development Corporation. He has now joined the Board of Directors of Joseph Lucas (Industries) Ltd., and of Lancashire Dynamo Holdings Ltd., in the latter case as Vice-Chairman of the Board.



TRIBUTE TO INSTITUTION REPORT

Members will be interested to read the following letter, recently received by the President of the Institution from the General Manager of New Departure, a Division of General Motors Corporation, in Connecticut :

" My dear Sir,

The Report, 'Quality, its Creation and Control', published by The Institution of Production Engineers, July, 1958, has just come to our attention. This effort is very impressive not only because it expresses the philosophy that we are attempting to follow, but also because it is so well written and concise yet covers the entire field of quality control as we know it today.

We should like to extend our compliments to you and to the group that did this work.

We are assuming that we may reproduce this for use in our own organisation. If this is not acceptable, please advise.

Very truly yours,
(Sgd.) Seth H. Stoner,
General Manager."

MIDLANDS REGION CONFERENCE

The third in the current series of one-day Conferences will be held at Coventry on Wednesday, 6th May, 1959, and will have the theme : " Measuring — Tomorrow's Production ".

A symposium of Papers on modern measuring techniques will be presented, to enable members to gain first-hand information concerning the many important advances in gauging methods and equipment that have become available to the production engineer in post-War years; advances which ensure the consistent and economical control of parts which must be supplied in large quantities, often to increasingly close limits of accuracy.

The speakers, drawn from the fields of research, manufacture and application of the equipment, will be Professor J. Loxham; Mr. C. J. Tanner; and Mr. K. F. Goode. It is expected that attention will be drawn to the developments in pneumatic and electronic gauging units which provide a high degree of discrimination, and to the introduction of many semi- or fully-automatic machines incorporating such devices.

The Institution is fortunate in having the facilities of the Matrix Hall, Fletchamstead, Coventry, placed at their disposal for the Conference by Sir Stanley Harley, M.I.Prod.E. During the day delegates will also be able to study the manufacturing facilities of The Coventry Gauge & Tool Company's works.

CORRESPONDENCE

From :

Mr. A. K. Thomas, Member, (Manchester)

Referring to the Paper, " Some Recent Developments in Spiral Bevel Gears " by Frederic Rochat (February, 1959, Journal), I wish to draw your attention to note 2 on pages 68 :–

> " All tooth spaces are progressively cut during uniform rotation of the gear blank (FIAT, KLINGELNBERG and OERLIKON methods)."

This statement is misleading, insofar as it creates the impression that only the above three Continental firms are makers of spiral bevel gear generators working on this principle.

As a matter of fact, in Great Britain this type of spiral bevel gear generator has been manufactured at Craven Brothers since 1941.

In this connection, also, I would like to refer to my article on " Design of Spiral Bevel Gears " (*Engineering*, 26th September, 1958) in which are mentioned under " References " the three firms : Craven, Fiat, Oerlikon.

From :

Mr. C. A. Gladman, Member (Sydney)

Just before Christmas I received through the post an Institution envelope which I expected would hold

DIARY DATES FOR 1959

April 16th/17th ... **The Seventh Aircraft Production Conference, Southampton.**

April 29th ... ... **The 1958 George Bray Memorial Lecture,** to be presented in London.
Speaker : **Mr. Mark Bogod,** Director, J. Lyons & Co. Ltd.
Subject : **" The Search for Productivity in a Food Industry."**

June 4th ... ... **Fifth Conference of Engineers Responsible for Standards,** Connaught Rooms, London. (See Supplement to this Journal.)

June 18th/19th ... Conference on **" Quality in Industry ",** Palace Hotel, Buxton. (See Supplement to this Journal.)

October 12th ... ... **The 1959 E. W. Hancock Paper,** to be presented in Bristol.
Speaker : **Mr. R. A. Banks,** Personnel Director, Imperial Chemical Industries Limited.
Subject : **" Human Relations in Industry."**

November 19th ... **The Annual Dinner,** Dorchester Hotel, London, W.1.

my copy of the November Journal. However, I was somewhat surprised, on opening the envelope, to find, not the Journal, but a publication entitled "Hair and Beauty".

As a member of the Sydney Section Committee I, of course, have become well acquainted with the endeavours of the Institution towards "broadening the base", but it had never occurred to me nor, I think, to other members of the Sydney Committee, that the production of hair and beauty was to be included within this compass. There is little doubt that there are many of us here, and I must include myself in this category, who would be more than interested in this field of production.

No doubt also there would be full scope for the application of the principles of methods study and materials handling to the working of hair into the exotic product designs illustrated in the Journal: no doubt it would also be possible to improve the design of the technologist's tools for more efficient cutting and shaping of the hair.

The heat treatment of the hair could also be a subject for fruitful study and, for those interested in the humanities, the effect of the work situation upon the customers' reactions could be subjected to operational research. But the greatest boon which activity in this new field could bestow would be to renew hope in those many long-despairing souls whose production line has dwindled to a mere hair's breadth throughout the years.

However, I have been an engineer too long to enter new fields and, much as I admire good hair and beauty, I would nevertheless like to continue my studies of the more orthodox production engineering by receiving the normal November Journal in due course.

news of members

Colonel J. A. Davies, Member, is now Assistant Managing Director (Production), of International Computers and Tabulators Ltd.

Dr. N. A. Dudley, Member, formerly Reader in Engineering Production and Head of the Department of Engineering Production at the University of Birmingham, has been appointed to the Chair of Engineering Production.

Mr. J. C. Bihl, Associate Member, will be appointed during mid-April for a period of some 12 months to the position of acting Head of the Technical Section, Rhodesian Railways, with the rank of Acting Housing Officer.

Mr. J. R. Brooks, Associate Member, is now General Works Manager of Brades Nash Tyzack (Sales) Ltd.

Mr. M. H. Choules, Associate Member, has relinquished his position with Lansing Bagnall Ltd., Basingstoke, to take up the appointment of Works Manager with Simmons & Hawker Ltd., Feltham.

Mr. R. Clark, Associate Member, has relinquished his appointment as General Works Manager of the Mettoy Co. Ltd., Swansea, and is now General Manager, London Branch, of Fredk. Braby & Co. Ltd., Crayford, Kent.

Mr. D. Gutteridge, Associate Member, has been appointed Manager of the new factory of Metal Containers Ltd., Wythenshawe, Manchester.

Mr. C. K. Haldar, Associate Member, has taken up a new appointment as Assistant Director-General for Statistical Quality Control in the Indian Ordnance Factories in Calcutta. He was until recently an Assistant Superintendent of Development in the Armament Research and Development Establishment in Poona. Mr. Haldar was Section Secretary of the Calcutta Section during 1955 - 1956, and has also served on the Section Committee.

Mr. H. G. Bottomley, Associate Member, formerly Chief Engineer with Messrs. Douglas Fraser & Sons Ltd., Arbroath, has been appointed General Manager of Landis Lund Ltd., Keighley. Prior to his employment with Douglas Fraser & Sons Ltd., Mr. Bottomley had been with the Lund organisation for eight years, reaching the position of Chief Draughtsman. During his time in Scotland, he served on the Dundee Section and Scottish Regional Committees.

Mr. W. H. Marley, Associate Member, has been appointed Works Manager of the Diesel Engine Division of North British Locomotive Co. Ltd. Mr. Marley is the Honorary Secretary of the Glasgow Section.

Mr. M. E. Reed, Associate Member, has relinquished his position with Edwards High Vacuum Ltd., Crawley, and has taken up an appointment as General Manager, Mayra Electronics Ltd., Purley.

Mr. K. W. B. Sharp, Associate Member, formerly Head of the Engineering Department of the Grantham College for Further Education, has been appointed Principal of Wolverton College of Further Education. He will take up his duties on 1st May.

Mr. L. Swan, Associate Member, has taken up the position of Production Manager with George Wilson Gas Meters Ltd., Jarrow, Co. Durham.

COMMUNICATIONS

Written discussion on Papers appearing in the Journal is invited for publication.

Contributions should be addressed to The Editor,

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10, Chesterfield Street, Mayfair, London, W.1

MEMBERS TRAVELLING OUTSIDE THE U.K.

Members who are visiting Australia, New Zealand India, South Africa or Canada are reminded that the Institution has local Sections in these countries, where they will be made very welcome by the Institution's Honorary Officers and members there.

Papers on subjects of interest to production engineers and managers are always welcomed, and any members who are visiting one of the Sections outside the U.K., and who would like letters of introduction, should inform the Secretary of the Institution at 10 Chesterfield Street, Mayfair, London, W.1.

GROUP PROVIDENT SCHEME

THE Institution has a Provident Scheme for its members in the U.K. The object is to safeguard members against the expense of private treatment for major illnesses, including surgical operations. Private treatment in nursing homes, hospital pay-beds and private specialists' consulting fees, do not come under the National Health Service, and the patient has to pay the full cost. The Provident Scheme is designed to enable members of the Institution, and their dependents, to make the best and speediest arrangements without having to worry about the cost, and to provide a measure of privacy during treatment which is not possible under the National Health Service. Thus the Scheme is not intended to displace the National Health Service, but to provide supplementary benefits.

Under the Institution's Group Provident Scheme, the British United Provident Association's standard rates of subscriptions are reduced by 20% and arrangements are made for the collection of subscriptions annually by Banker's Order made payable to the Institution. Members are entitled to benefit immediately on acceptance and are not subject to the usual three monthly waiting period.

If you are already a private member of the B.U.P.A. and under 65 years of age, you can apply to transfer to the Institution's Group Scheme and get the benefit of 20% reduction in fees. A refund of any balance of your current individual subscription which may be outstanding, would be made.

Members interested in joining this Group Scheme are asked to write to the Secretary of the Institution, asking for full details and an application form.

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ADDITIONS AND PAPERS RECEIVED

Members are reminded of the following Library rule, which is frequently ignored:

"The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

ADDITIONS

Association of Supervisory Staffs, Executives and Technicians, London. **"Automation — A Challenge to Trade Unions and Industry."** *London, the Association,* 1956. 27 *pages.* 1s.

Booth, Andrew, D. **"Automation and Computing."** *London, Staples Press,* 1958. 158 *pages. Diagrams.* 25s. "This book is an attempt to bridge the gap between the superficial accounts of electronic computers and automation which appear periodically and the specialist monographs . . . It is hoped that it will be intelligible to the educated layman who can if he wishes skip the more technical material without detriment to his general understanding. At the same time, sufficient material is included to form an introduction suitable for university graduates in mathematics, science and engineering . . ." Contents: History of automation and of analogue and digital calculation — The logical design of digital calculating machines — The physical basis of computer design — Programming for a digital computer — Analogue computers — Automation in clerical work — The control of continuous processes — Automatic machine tools and assembly processes — Strategic and economic planning — Non-numerical applications of computing machines.

British Institute of Management, London. **"The Challenge of Change."** Report of the 13th National Conference, held by the British Institute of Management, at Brighton . . . November, 1958. 247 *pages. Illustrated.*
In his opening address to the Conference, Sir Harold Howitt summarises the problems presented to management by changing social and industrial structures, and discusses them under the following headings: The industrial structure — Wages and labour relationships — Profits and prices — Efficiency. The Papers presented are the following: The role of the top executive in a large organisation (Sir John Elliott, Chairman, London Transport Executive) — Advisory services in the smaller firm (G. L. Page) — The new consumer (Mark Abrams) — The science of inventory control (A. Battersby) — Wages and national economy (S. C. Hills) — Efficiency comparisons in large multi-unit organisations (J. P. Wilson) — Cost accounting under conditions of automation (A. Kenyon) — Selling abroad: are we good enough? (B. H. Dyson) — The Nestlé's training centre at Lausanne (Larke E. Myers and F. A. Kriby) — Careers for our daughters in a changing world (L. E. Charlesworth) — Forecasting and controlling the return on capital employed (J. A. Scott) — Technical modernisation and new freight charges on British Railways (Sir Reginald Wilson) — The effect of quality of administration on technical and commercial efficiency (A. C. Durie) — The influence of sales policy on production efficiency (R. S. Liddle) — Financing industry (J. B. Kinross) — Vertical co-operation for better forecasting and planning (A. M. Alfred) — Purchasing management and its contribution to efficiency (J. Murray Grammar) — Security for the employee (R. R. Hopkins) — Design in the home (Stephen Garrett) — Closing address and summing-up (The Earl of Verulam).

Casey, Robert S. (and others). **"Punched Cards: Their Applications to Science and Industry."** Edited by Robert S. Casey, James W. Perry, Madeleine M. Berry and Allen Kent. 2nd edition. *New York, Reinhold; London, Chapman and Hall,* 1958. 697 *pages. Diagrams.* The first edition of this book was published in 1951. In their preface the editors say: "Some idea of the rapidity with which the field has grown may be gained from the fact that the bibliography of uses contains 400 entries compared with 276 entries in the first edition. This great increase is reflected in the extension of the practical applications section . . ." The general plan of the 2nd edition is similar to that of the first. A few chapters are unchanged, but most have been re-written or enlarged. A few of the chapters (listed by the editors in the preface) provide an introduction to the subject for those unfamiliar with punched cards. The book is divided into three sections:

1. Fundamental machine considerations (e.g., Elementary manipulations of hand-sorted punched cards — Commercially available equipment and supplies).
2. Practical applications of punched cards and related devices (e.g., Anaesthesia record cards — Classification, searching and mechanisation in the U.S. Patent Office — The use of punched cards in linguistic analysis).
3. Fundamental considerations in coding and design.
4. Future possibilities.

The equipment described is American, but this does not invalidate the book, since similar equipment is available in the U.K.

Hume, K. J., and Sharp, G. H. **"Practical Metrology."** Vol. 3. *London, Macdonald and Co.,* 1959. 88 *pages. Illustrated. Diagrams.* 10s. 6d.
"Practical Metrology" will be published in four volumes of which this is the third. It provides collections of laboratory experiments with instructions for their performance, and the recording and assessment of results. All the experiments correspond to examples encountered in industrial metrology work. The first two volumes were published in 1953 and 1956 respectively, and contained descriptions of experiments of a simple nature (e.g., measuring plug gauges; checking straight edges; measuring pitch error in a screw gauge). The contents of Volume 3 are: To measure the effective diameter of a ring screw gauge using a horizontal comparator or measuring machine — To set and calibrate an engineers block level — To compare the lengths of two end gauges on a N.P.L. type level comparator — To measure the included angle of a taper plug gauge using an autocollimator — To calibrate a dial gauge — To measure an angular plate gauge using an optical dividing head — To calibrate a divided circle using two microscopes — To compare two slip gauges using an optical flat — To test the flatness of a surface plate using a block level — To check the involute profile of a spur gear using a dividing head.

Kinney, Gilbert Ford. **"Engineering Properties and Applications of Plastics."** *New York, Wiley; London, Chapman and Hall,* 1957. 278 *pages. Diagrams.* 54s.
This book describes the chemical, mechanical and physical properties of the various kinds of plastics, and lists their end uses. The plastics are dealt with more or less in increasing order of complexity. Separate chapters deal with fabrication methods and with thermal, optical and electrical properties. Contents: The general nature of plastics — Polyethylene — Polyvinyl chloride — Polystyrene — The Acrylic plastics — Other vinyl type plastics — The cellulose plastics — Phenolic plastics — The Amino plastics — Polyesters, polyamides and epoxies — Silicones — The Rubbers — Moulding methods — Engineering properties — Thermal properties — Optical properties — Electrical properties — Chemistry of plastics — Tables (of chemical formulae, general characteristics and typical applications of representative plastics).

Koontz, Harold, and O'Donnell, Cyril. **"Principles of Management."** An analysis of managerial functions. 2nd edition. *London, New York, etc., McGraw-Hill,* 1959. 718 *pages.*
The first edition of this book was published in 1955. Several chapters have been added in this edition and other chapters expanded. The book deals with the basic principles of organisation and administration, under six major headings: The basis of management — Organisation — Staffing — Direction — Planning — Control. In the new chapter on line and staff authority relationships, an attempt is made to define these two kinds of authority, with examples of their operation in the American Army, the Roman Church and some large American companies. The book does not deal in detail with any of the specialised managerial techniques, such as budgetary control, production control, operational research, but places them in perspective and indicates their uses.

"Lubrication Science and Technology." Vol. 1, No. 2. *London, New York, etc., Pergamon Press,* 1958. 346 *pages. Illustrated. Diagrams.* (American Society of Lubrication Engineers, Transactions, Vol. 1, No. 2.) 70s.
Comprises Papers by various authors on different aspects of lubrication. Contents: Plane siders of finite width (D. F. Hays) — Determination of optimum proportions for hydrostatic bearings (A. M. Loeb and H. C. Rippel) — The viscosity wedge (A. Cameron) — Parallel surface thrust bearing (A. Cameron and W. L. Wood) — Lubrication of high-speed, high-temperature thrust ball bearings (G. S. Reichenbach, J. B. Accinelli and S. J. Beaubien) — The effect of lubricant viscosity and type on ball bearing fatigue life (A. J. Anderson and T. L. Carter) — Investigation of oil additives for boundary lubrication of railroad journal bearings (A. Miller and A. A. Anderson) — Influence on temperature on boundary lubrication (C. W. Cowley, C. J. Ultree and C. W. West) — Fretting of hardened steel in oil (J. R. McDowell) — Wear and frictional characteristics of some nickel base alloys (R. A. Kozlik) — Investigation of wear by electron diffraction (L. M. Niebylski, M. Antler and L. O. Brockway) — A study of the effect of wear particles and adhesive wear at high contact pressures (E. B. Sciulli and G. M. Robinson) — Wear of cobalt base and stainless materials in high purity water (N. B. Dewees) — Cam and tapper lubrication, 3: Radioactive study of phosphorus in the EP film (E. H. Loeser, R. C. Wiquist and S. B. Twiss) — Workpiece compatibility of ceramic cutting tools (M. C. Shaw and P. A. Smith) — Discussion on a fundamental study of synthetic sapphire as a bearing material (L. F. Coffin, Jr.).

"Modern Foundry Practice." Edited by E. D. Howard, with contributions by 18 specialist authors. 3rd edition. *London, Odhams Press,* 1958. 464 *pages. Illustrated. Diagrams.* 30s.
Previous editions of "Odhams Foundry Practice" were published in 1943 and 1953. It is a basic textbook for students and apprentices, with many diagrams and illustrations. The text of this edition has been revised and sections on important new foundry materials, such as epoxy resins, and on new processes such as shell moulding, have been added. Contents: Introduction — Ferrous metals — Heat treatment in foundry — Non-ferrous alloys — Aluminium alloys — Melting furnaces — Pattern equipment (with sections on heavy pattern equipment; aluminium pressure-cast pattern plates; cast epoxy-resin patterns) — Moulding sands and dressings — Moulds and mould making — Cores and core making — Moulding machines — Modern moulding developments — Fettling practice — Foundry mechanisation — Inspection of castings — Foundry work training.

"Operational Research in Practice." Report of a N.A.T.O. Conference, Paris, 1957. *London, New York, etc., Pergamon Press for and on behalf of Advisory Group of Aeronautical Research and Development, North Atlantic Treaty Organisation,* 1958.. 201 *pages. Illustrated.* 84s.
The Conference was attended by representatives of N.A.T.O. countries, who gave accounts of how operational research is being used, and has been used in their respective countries, and discussed its potentialities. The experience gained during World War II of the mathematical solution of military problems is the basis upon which operational research has developed, and it is natural that an official Conference of N.A.T.O. countries should emphasise the military aspects of the subject. Non-military, industrial uses of operational research are, however, discussed also, including the actual and potential applications of specific techniques such as linear programming. An introductory Paper on the meaning and function of operational research is followed by a Paper on the need for operational research, and resumés of the status of operational research in seven N.A.T.O. countries (Italy, Netherlands, Denmark, Norway, Turkey, Germany and France). The rest of the contents are as follows: Development planning; operational research aspects (James E. Lipp) — Some examples of systems analysis (Handel Davies and K. E. Silman) — Scientific aids to decision making: a perspective (J. R. Goldstein) — A method of evaluating the efficiency of a reporting system in aerial defence (Colonel Ferré (in French)) — Methods of air defence over Germany in World War II (Theodore Benecke) — Systems of evaluation and military planning (J. W. Abrams) — Linear programming (Merrill M. Flood) — Logistic and transport operations (Glen D. Camp) — Economy and strategy (P. Masse (in French)) — Operational research in action (Francesco Brambilla (in French)) — War games (Robert D. Specht) — Organisation for operational research in the United Kingdom (G. N. Gadsby) — Organisation for operational research in the U.S.A. (Joseph F. McCloskey) — Selection and training of operational research scientists (Hugh M. Cole) — Future fields for operational research in the N.A.T.O. nations (H. A. Sargeaunt).

PAPERS RECEIVED

The following Papers have been received and may be borrowed by members:

2303 — "Bandsaws and Their Manufacture" by R. D. Hind, Grad.I.Prod.E.

2317 — "The Iron and Steel Industry in the U.S.S.R." by Professor V. I. Yavosiky (presented to the Bombay Section).

2318 — "Design and its Development" by A. Miller, M.I.Prod.E. (presented to the Bombay Section).

2319 — "Management Structures" by J. B. Shearer (presented to the Bombay Section).

2320 — "A Brief Survey of Transformer Production Techniques" by S. Szafranski (presented to the Bombay Section).

2323 — "Tracer Controlled Machining Operations" by C. E. Waller (presented to the Melbourne Section).

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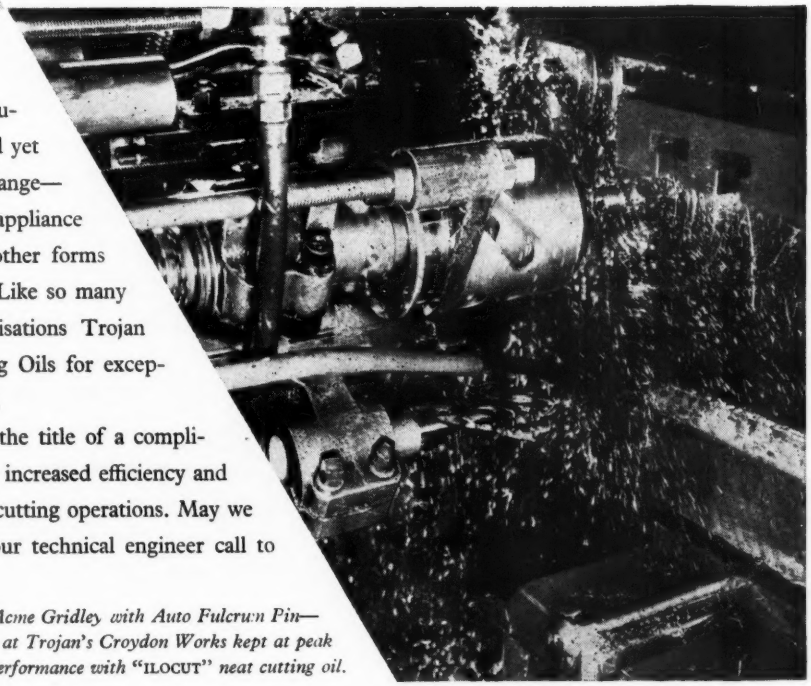

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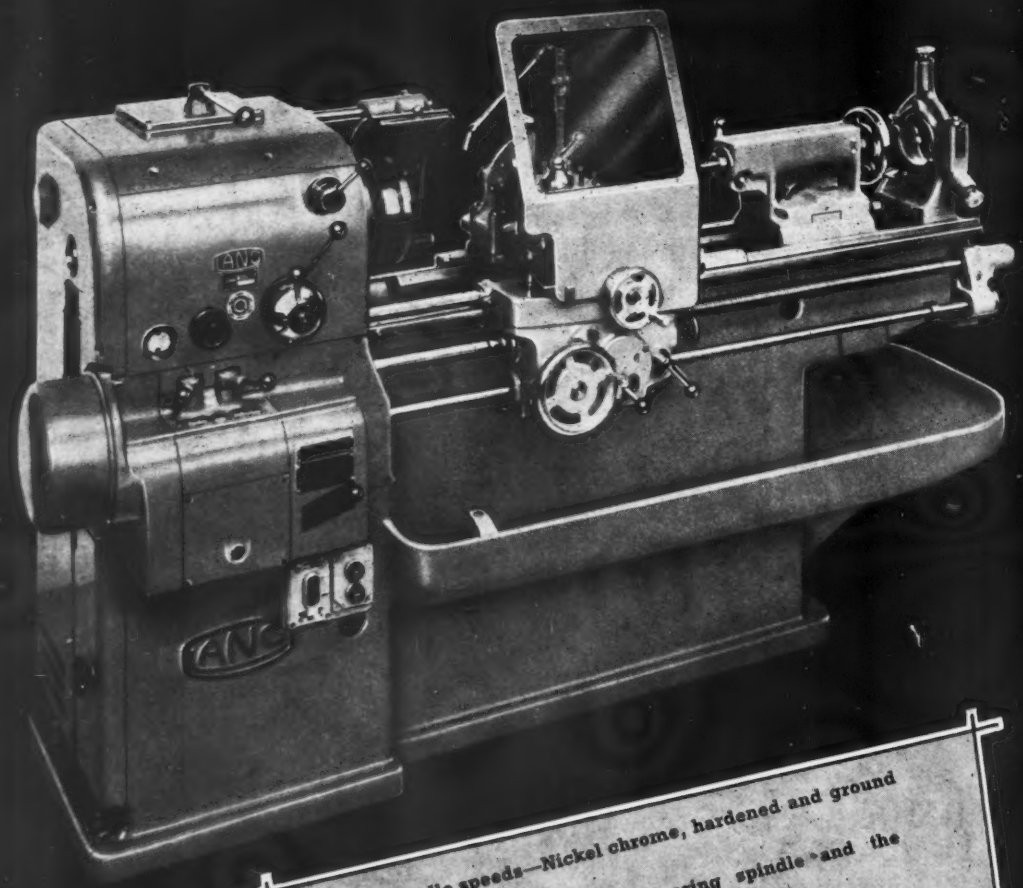

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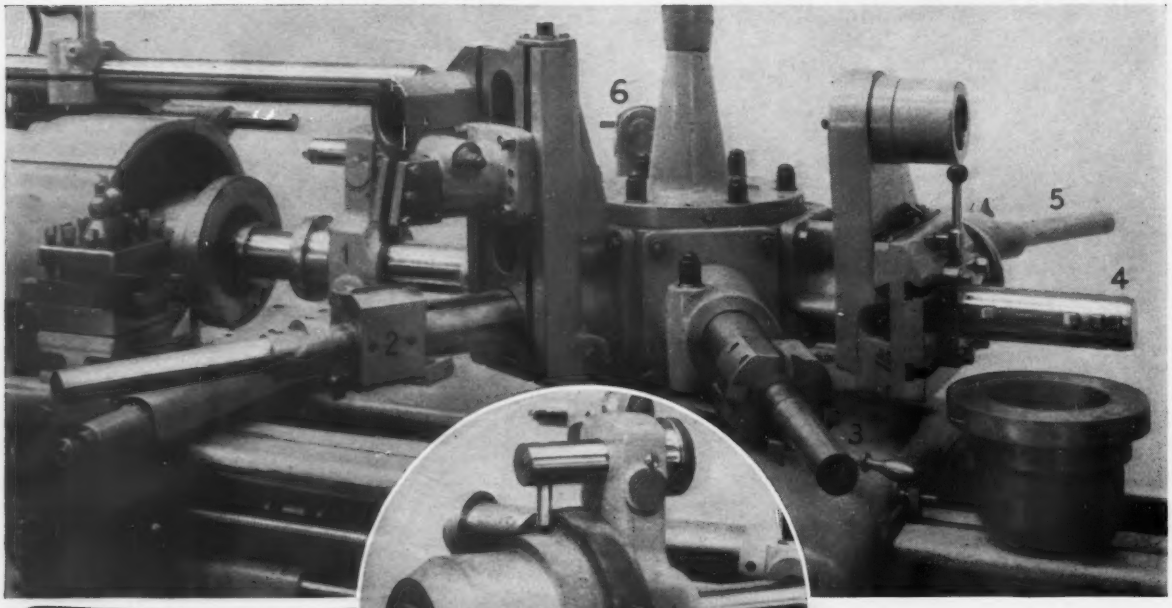

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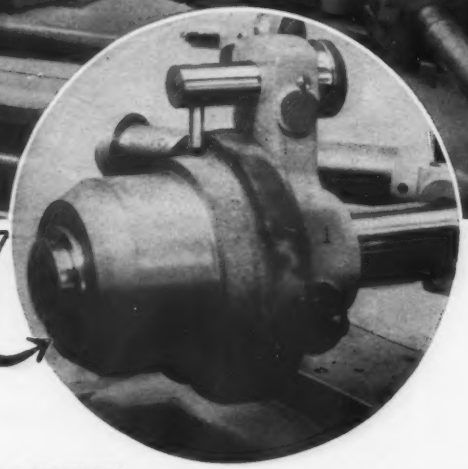

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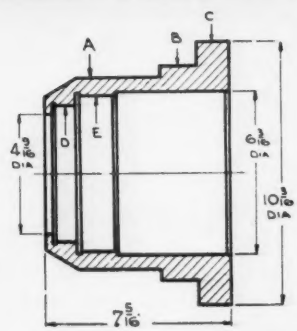
No. 8 TURRET LATHE

FITTED WITH 15in TUDOR 3-JAW CHUCK

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Chuck on A (using Loading Attachment) - Rough Face and Rough Turn C (1st cut)	1	—	—	—	—
	—	Front 1	85	235	48
2. Rough Bore $6\frac{3}{16}$ and $4\frac{9}{16}$ and Rough Turn C - - - - - - - -	—	—			
	2	—	85	230	70
3. Rough Bore D and E - - - - -	3	—	85	133	70
Rough Turn B and Face Back of Flange	—	Front 2	85	225	70
4. Undercut and Chamfer Bores (Recessing Toolholder) - - - - - - - -	—	—			
	4	—	85	133	Hand
Microbore D, E and $6\frac{3}{16}$ dias. - -	5	—	175	285	98
5. Finish Turn C - - - - - - -	—	Front 3	175	465	70
Finish Double Face Flange - - - -	—	Front 4	175	465	70
6. Remove Part from Chuck (using Unloading Attachment) - - - - -	—	—			
	6	—	—	—	—



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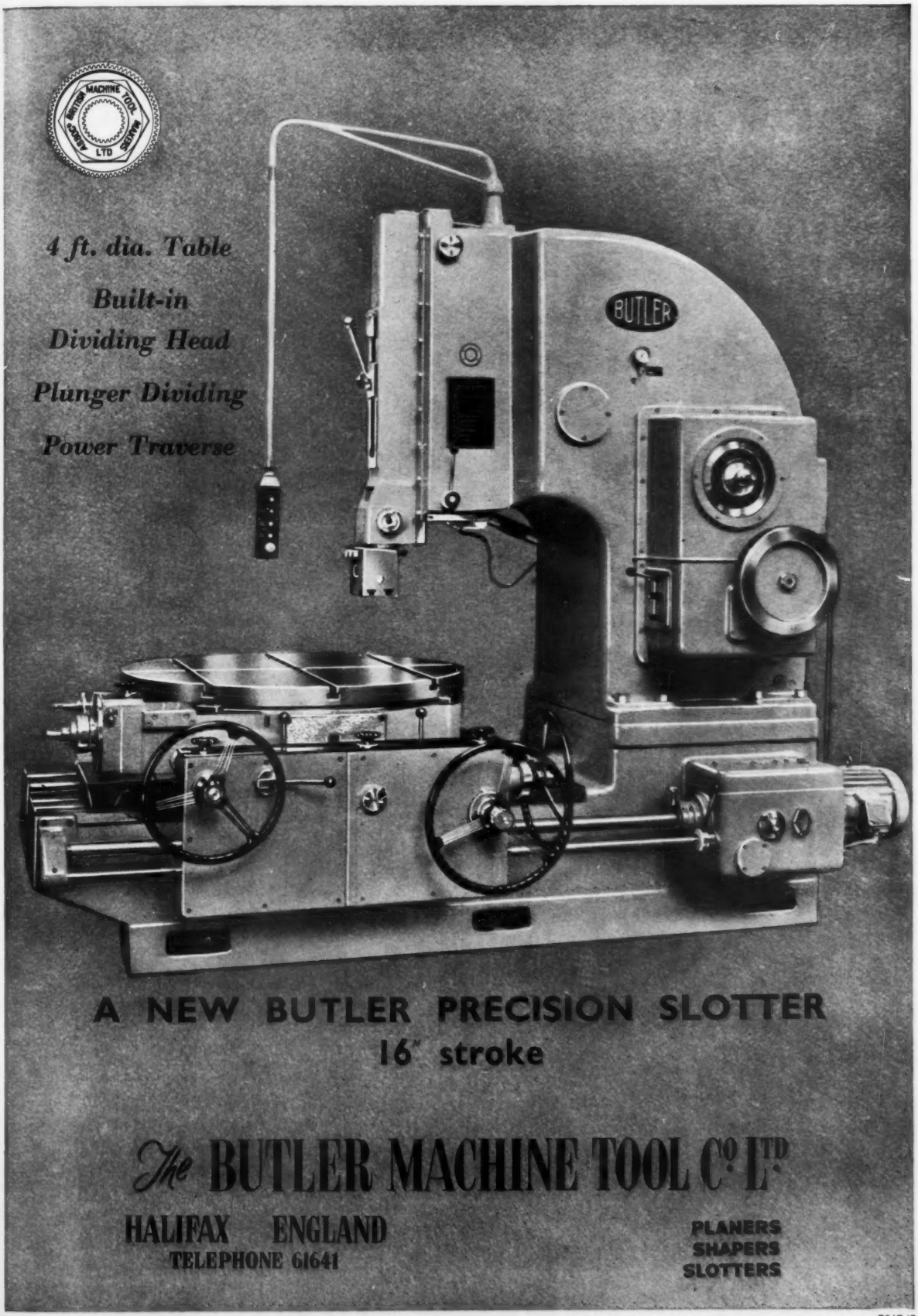
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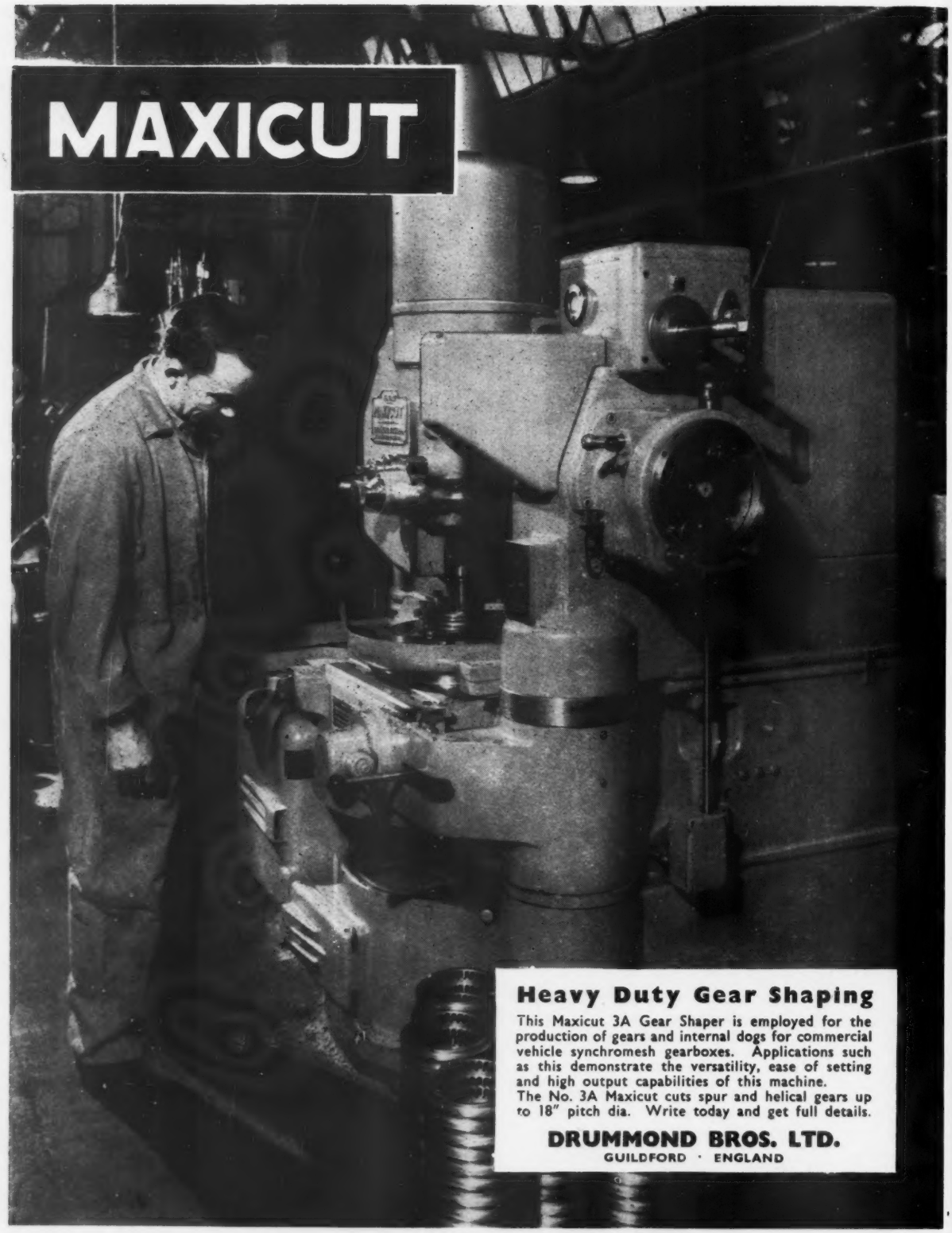
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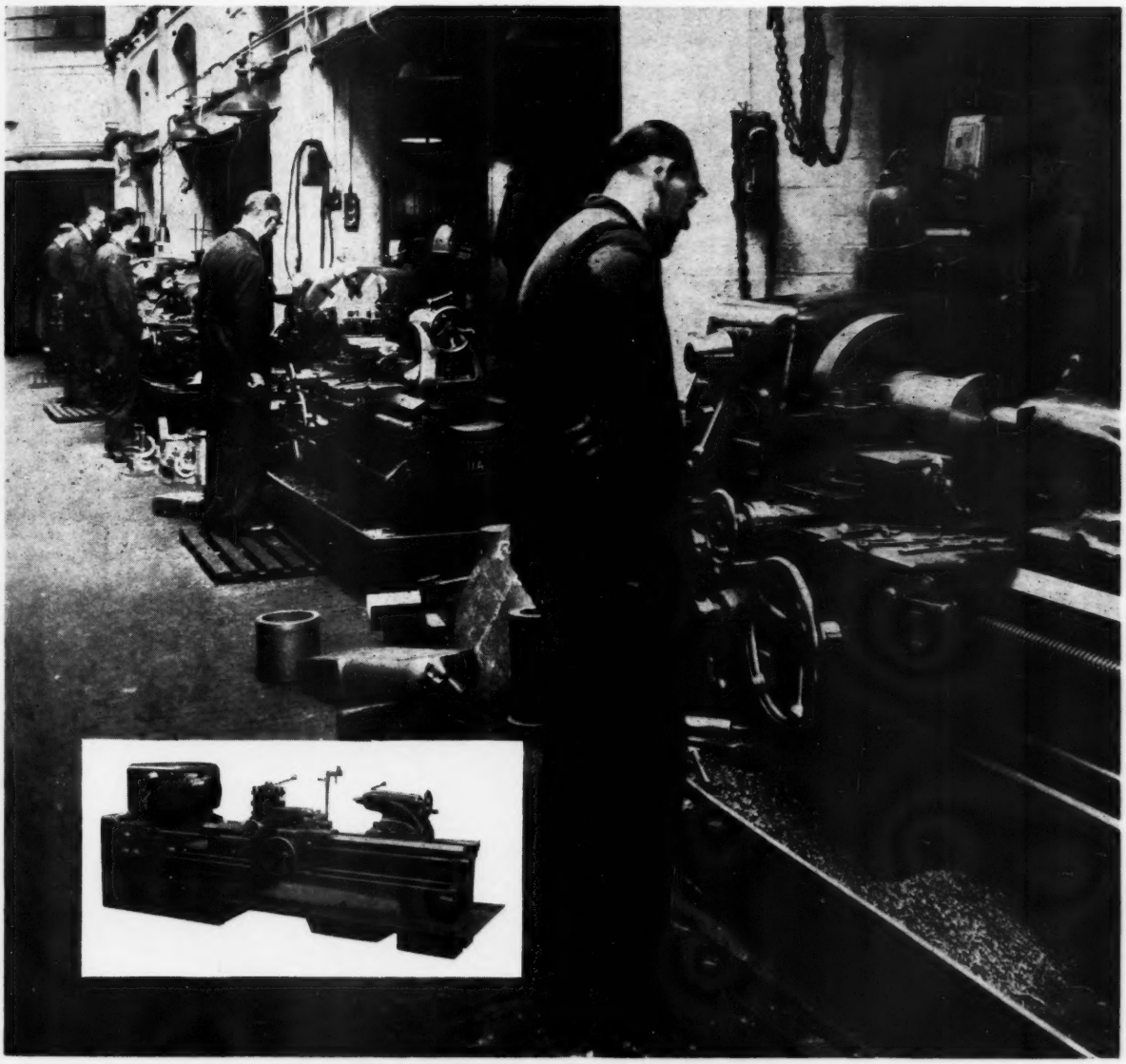

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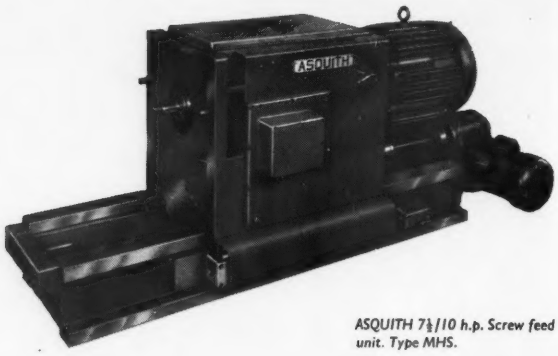

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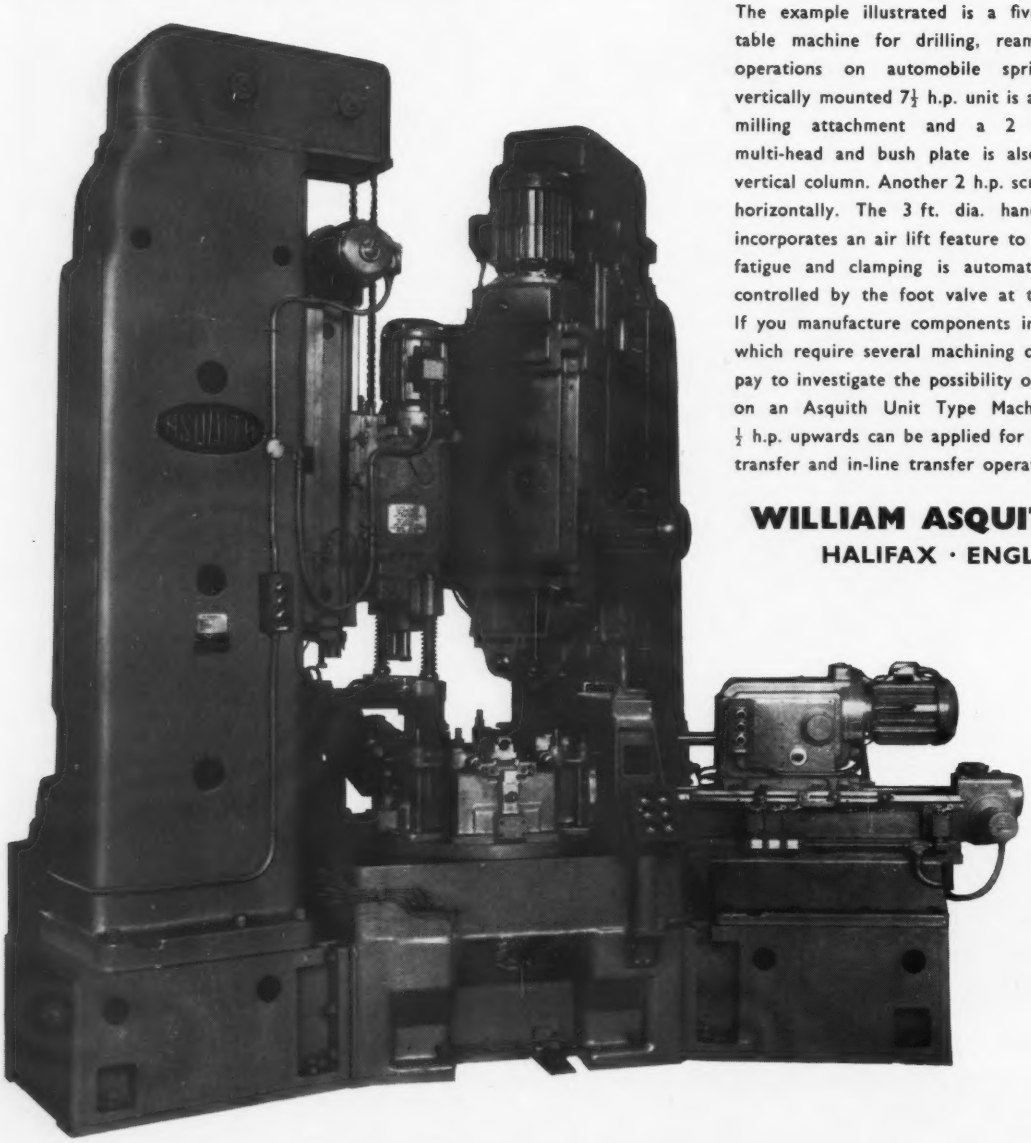

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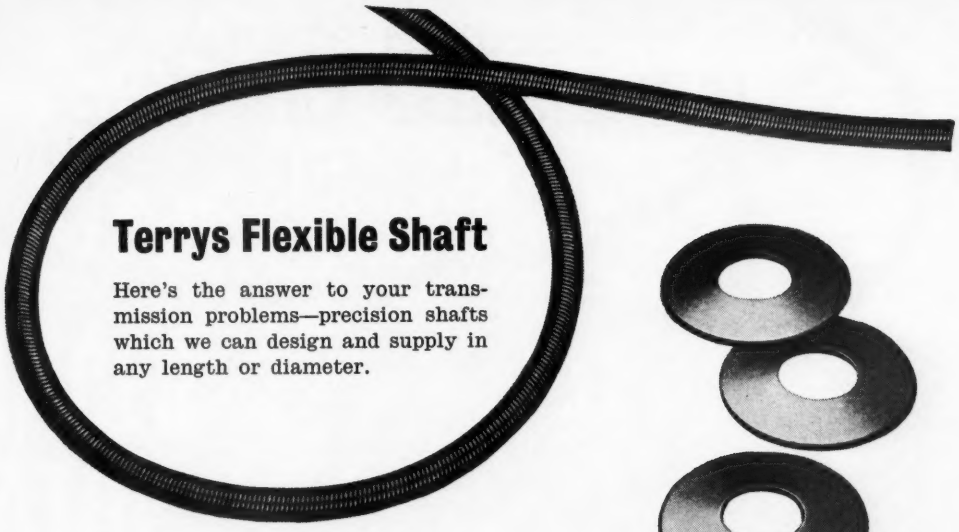

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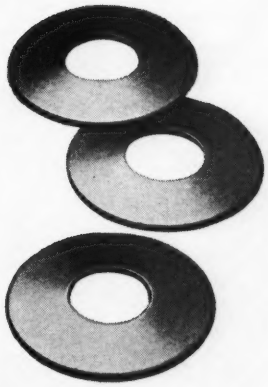

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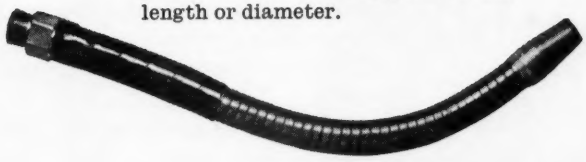

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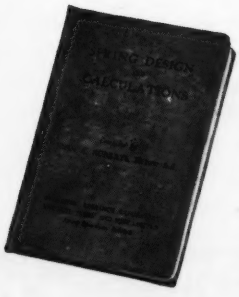

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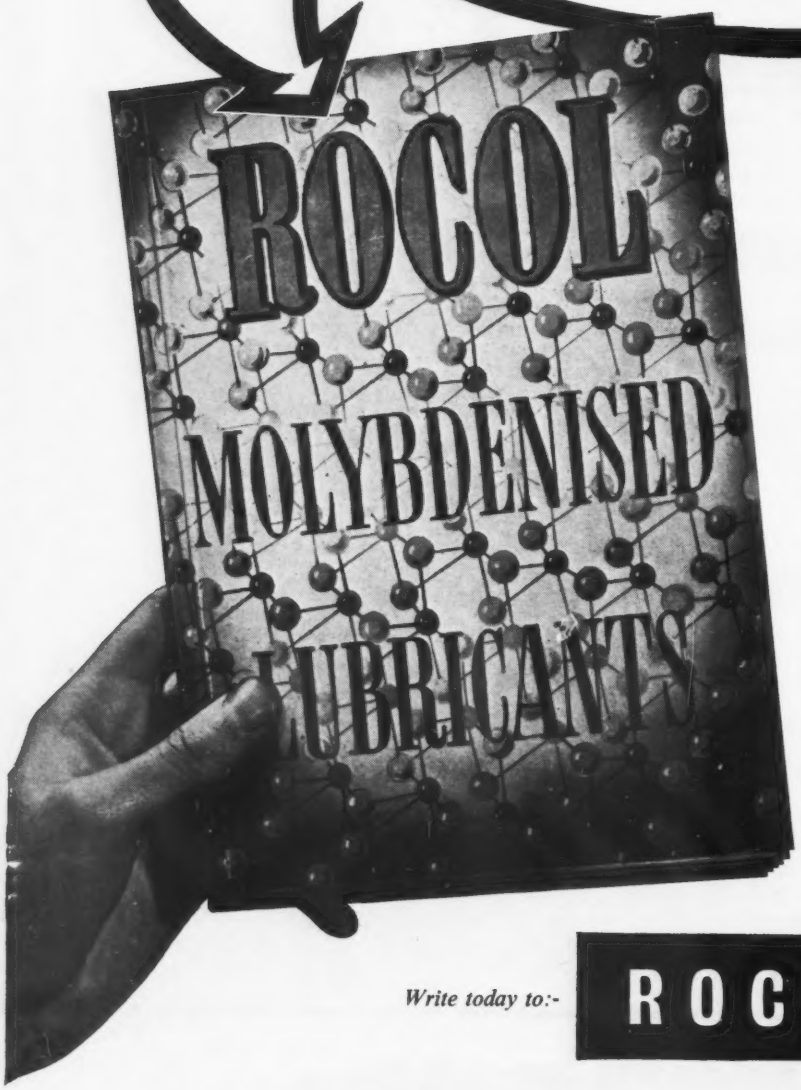

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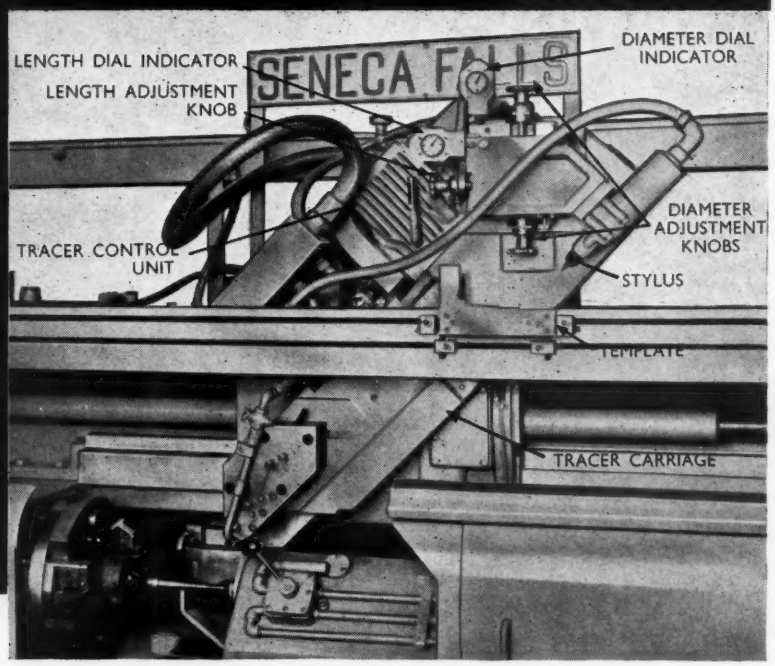

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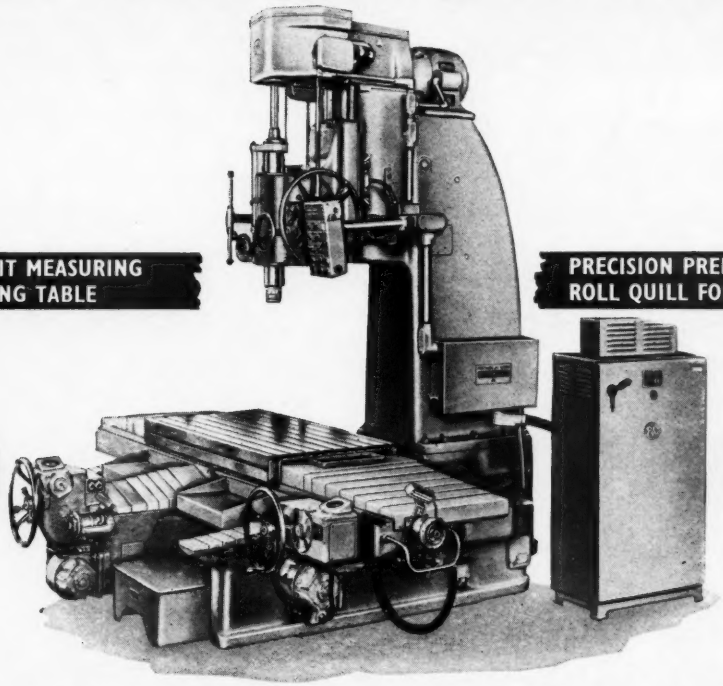

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PRECISION PRELOADED BALL ROLL QUILL FOR HIGH ACCURACY

LOCATING, BORING AND CHECKING TO .0002"

LOWER COST— PRECISION BORING

TABLE SIZE 36" × 72"

NUMBER 4E

Profitable manufacturing of precision products demands that the basic tools of production — jigs, fixtures, dies, moulds, etc. — be made faster, more accurately and more economically. Locating, boring and checking to .0002 of an inch, P. & W. Electrolimit Jig Borers combine extreme accuracy with faster, easier operation than ever before possible. All your tool room jobs — small, large, simple, complex, normal or very difficult — are produced better at lower cost.

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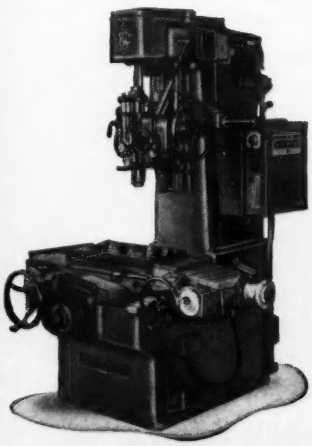
Machine Tool Division
Otterspool Way, Watford-by-Pass, Hertfordshire.

Head Office
P.O. Box 74, Whitechapel Road, London, E.1.

Branches
Alperton, Birmingham, Bristol, Glasgow, Leeds, Manchester



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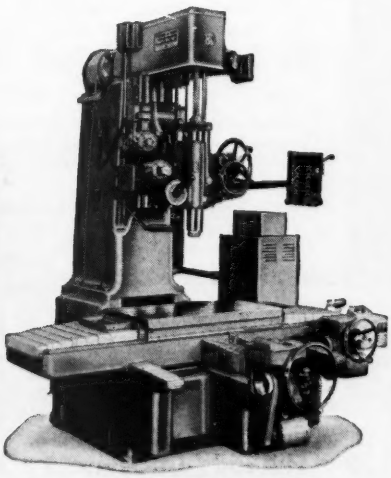

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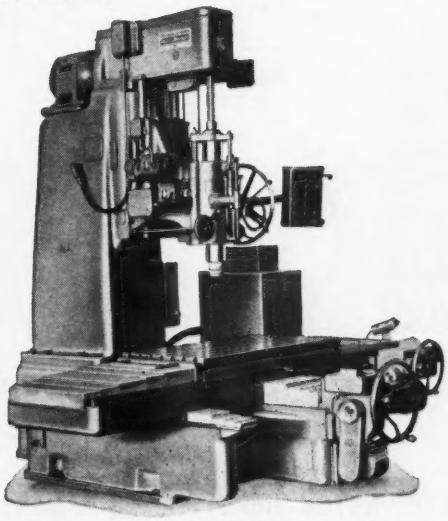

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The Teddington Gauging system has inherent advantages which provide fast, positive, trouble-free measurement combined with extreme accuracy.
The *standard* range of Pneumatic Gauges covers all commonly met gauging problems. It includes equipment for manual inspection, automatic gauging, and machine tool control.

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Teddington also provide a complete service covering the design and development of special purpose equipment for all applications, including data-reduction and print-out systems for statistical analysis where required.
Let us solve your problems of dimensional measurement or control, our proposals will *cost you nothing*.

MODEL 88 PNEUMATIC SIZE CONTROL for the automatic dimensional control of work on machine tools. This inexpensive unit for "in process" or "post process" gauging provides a completely flexible control for grinding, fine turning and other precision machining. It combines light indication with multi-stage corrective signalling for the machine controls. Write for leaflet N10.

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AUTOMATIC Teddington CONTROLS

The IDEAL range of RELAYS...

for

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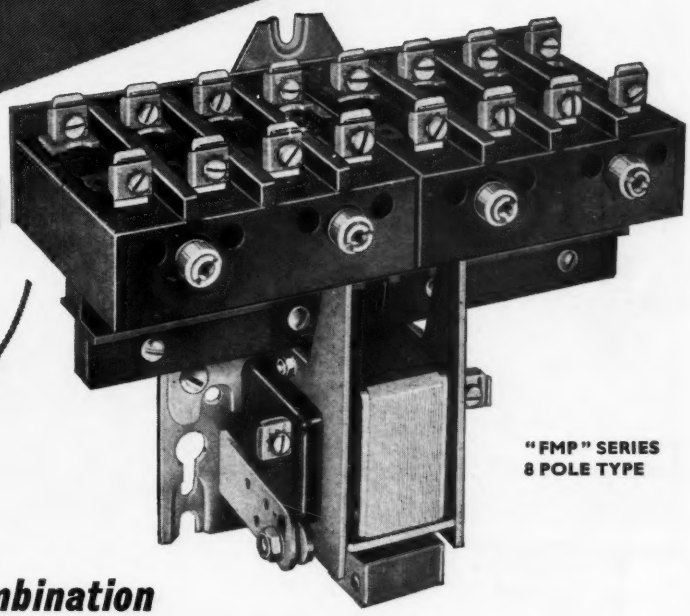

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8 POLE TYPE

- ***ANY* combination of normally open or normally closed poles up to *EIGHT*.**
- **Contact rating *15 AMPS* at *600 VOLTS* A.C**
- **Available as 'plug-in' types**
- **Latching attachment optional**

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A.19

More wear resisting than Tungsten Carbide

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ELWORTH WORKS SANDBACH CHESHIRE

2nd May, 1957

ADPT/CAM.
EJP/PB/LAB.

Messrs. Glostics Ltd.,
Tuffley Crescent,
Gloucester.

For the attention of Mr. A.D.P. Tallents.

Dear Sirs,

In January 1955 you supplied us with two shot blast nozzles in Carbon Tetra Boride. These were immediately put into use in the shot blast cabinets in our Heat Treatment department, working at an air pressure of 40 to 60 lbs/sq. in., and using 30 mesh angular chilled cast iron grit as the abrasive.

It is estimated that each nozzle has now been in service for more than 5,000 hours, and recent dimensional checks show the amount of wear to be almost negligible. We are advised by you that the original nozzle bore diameter was ⅜", and it will be seen from the following figures that little, if any, wear has taken place.

Bore Size at Throat of Nozzle .3745" to .3742"
Bore Size 1" from Throat .3650" to .3648"

We feel that an outstanding performance such as this should not go unnoticed, and you are therefore at liberty to use the information contained in this letter in any way you wish to further the publicising of C.T.B. nozzles.

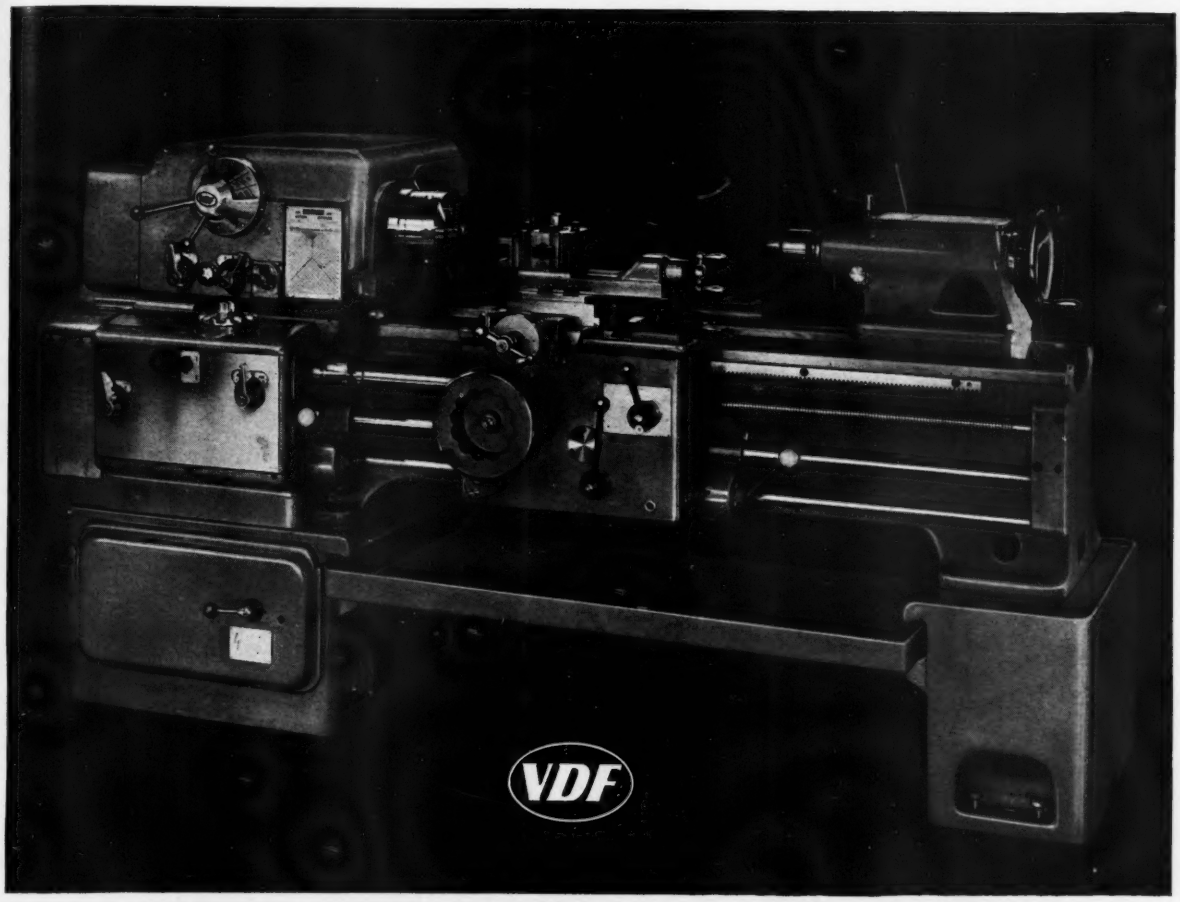
Yours faithfully,
for FODENS LIMITED.

E.J. PHIPPS,
CHIEF METALLURGIST.

C.T.B SHOT BLAST NOZZLES

Glostics Ltd

AGENTS : IMPREGNATED DIAMOND PRODUCTS LTD : TUFFLEY CRESCENT : GLOUCESTER



Do more jobs more easily with VDF Lathes – Types 36 and 44

- extremely versatile, with a high degree of finish.
- up to 30 spindle speeds from 11 to 2240 r.p.m. Also available with Boehringer-Sturm oil drive giving infinitely variable spindle speeds.
- smooth, even transmission and control at all speeds.
- large base area and box section construction ensures exceptional rigidity.
- six models available.
- a wealth of additional equipment is offered.
- fully descriptive literature on request.

BRIEF SPECIFICATION

	Type 36	Type 44
swing over bed	15¼″	18″
centre distance up to	118″	118″
height of centres	7½″	9″
main spindle bore	2″	2″
no. of speeds	18 or 30	18 or 30

(or infinitely variable)

Sole British Agents

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Machine Tool Co. Ltd

Hythe Works, The Hythe
Staines, Middlesex
Telephone
Staines 5076 (5 lines)
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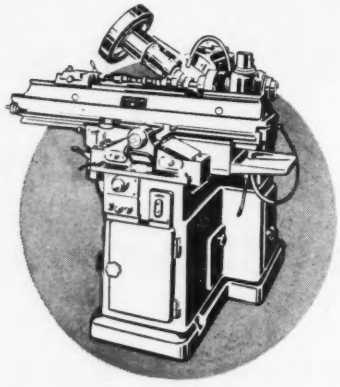
For Long Splines

Taper or Parallel Serrations *plus* High Angle Spiral Gears

DOWDING

H.7 HORIZONTAL UNIVERSAL HOBBER



Powerful and rigid. Suitable for climb or orthodox hobbing. Built-in differential for helicals. Heavy duty or high spiral angle hob heads. Taper hobbing attachment available which also permits combined plunge and axial feeds to be used for hobbing gears in between shoulders.

7″ DIAMETER, 8 DP., 18″ HOBBING LENGTH, 24″ BETWEEN CENTRES, SPINDLE BORED 3″ DIA.

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SPECIFICATION

Swing over bed 11"
Swing in gap 18½"
Between centres 24" or 40"
8 or 16 spindle speeds

11" SWING
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With inbuilt hydraulic copying equipment
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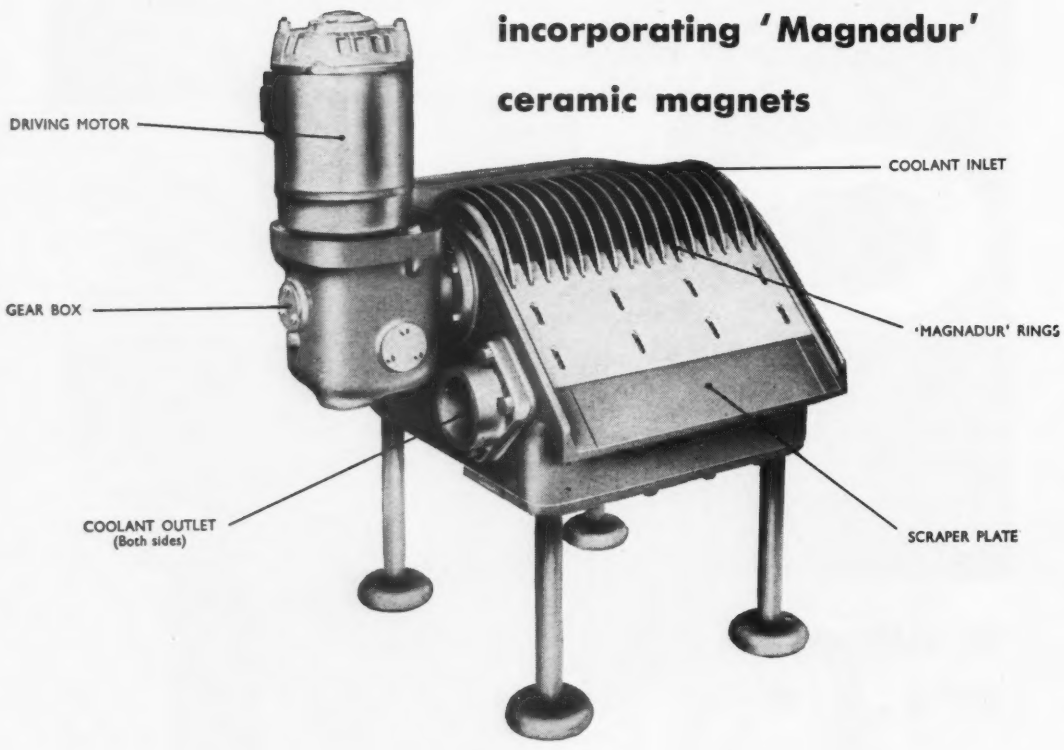
Increase production with NEW

PHILIPS 'Magna-Drum'

COOLANT CLARIFIER

incorporating 'Magnadur' ceramic magnets



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- ✱ *Completely automatic.*
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The heart of the New Philips 'Magna-Drum' coolant Clarifier is a compact unit which is magnetic over its whole surface area, and incorporates 'Magnadur' high power ceramic magnets. The equipment will filter straight cutting oils or soluble oil coolants without any modification. A very high proportion of grinding abrasive is always entrained in the ferrous swarf collected. Standard 'Magna-Drum' Clarifiers are available for handling flows of 300 g.p.h. to 7,500 g.p.h. British Patent No. 765495.

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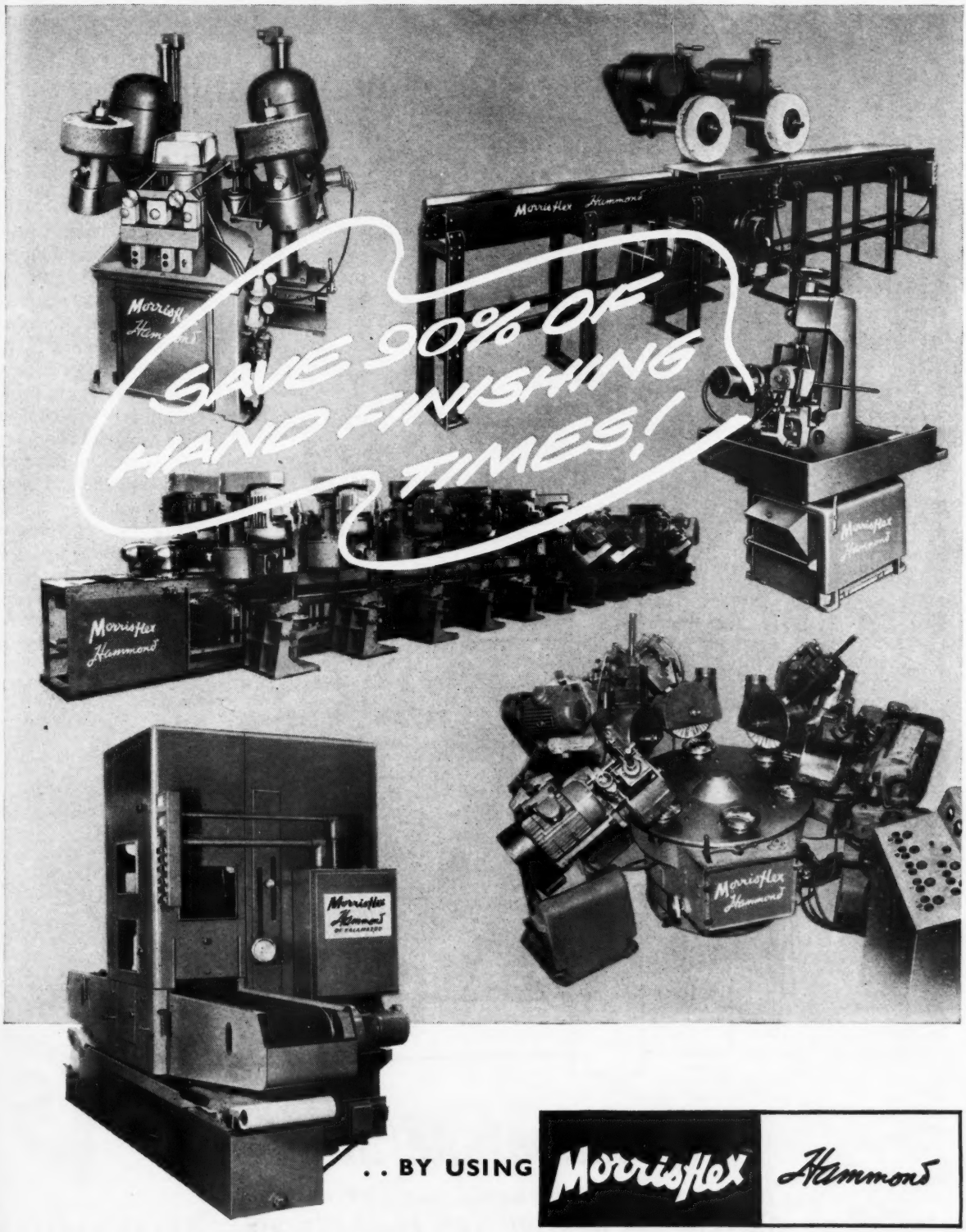

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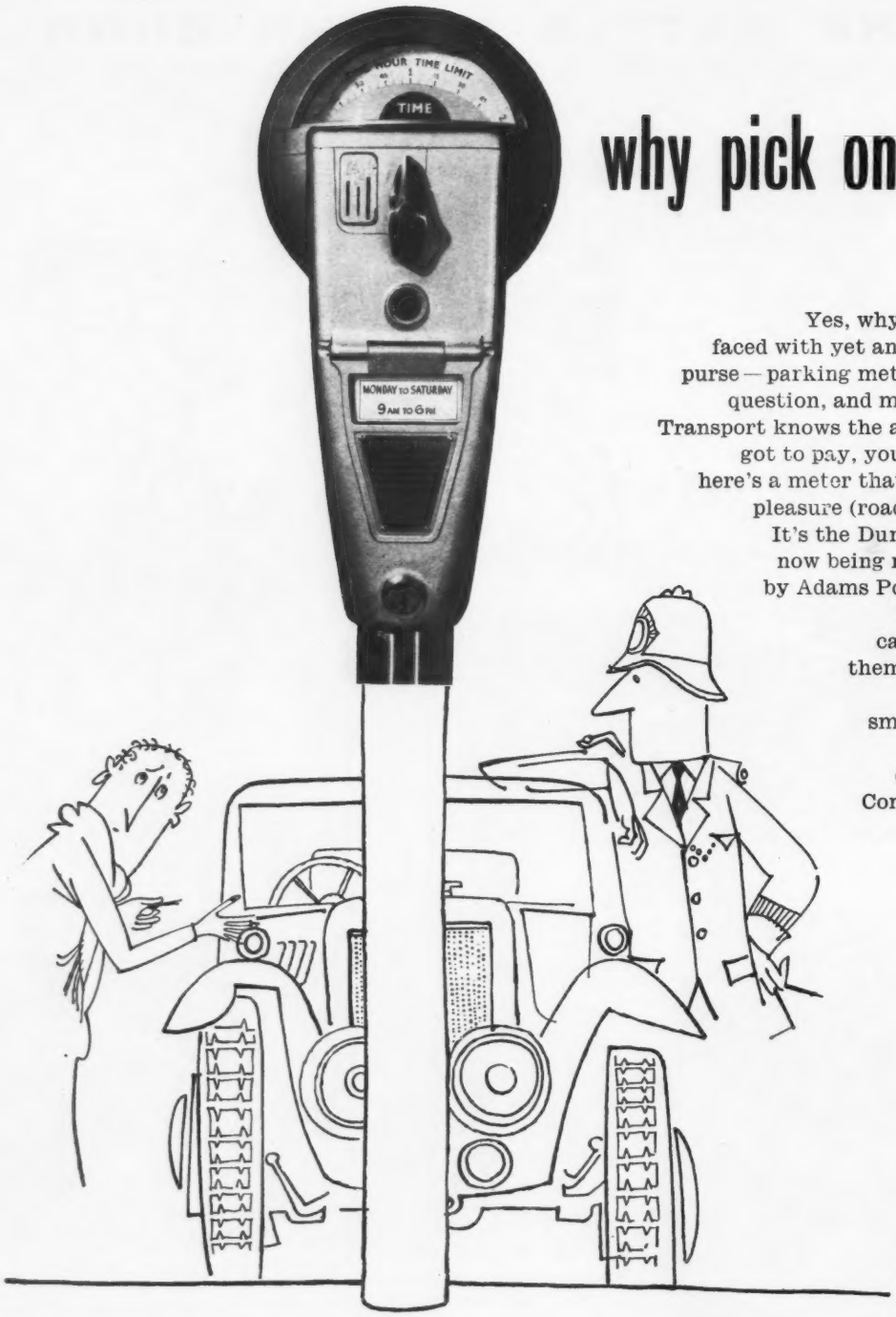
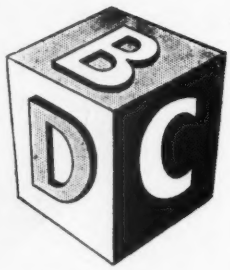


why pick on us?

Yes, why? asks the motorist, faced with yet another demand on his purse — parking meters. Well, it's a good question, and maybe the Minister of Transport knows the answer. But if you've got to pay, you've got to pay — and here's a meter that'll make it almost a pleasure (road funds to you, too!). It's the Duncan Miller Model 60, now being made in this country by Adams Powel Equipment Ltd. *They* picked on us to cast the parts — 90% of them in zinc. The largest weighs 5¾ lbs., the smallest 0.013 lbs. Have *you* got a pressure die casting problem? Come and park it on us.



the whole in one

CERTIFIED ZINC ALLOY ZAMCA DIE CASTERS

BRITISH DIE CASTING AND ENGINEERING COMPANY LIMITED

EDWARD ROAD · NEW BARNET · HERTS · TEL · BARNET 9211

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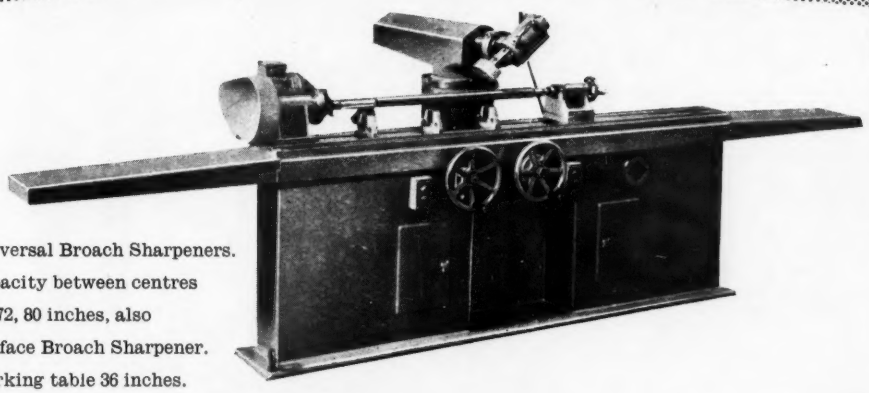
NORTH SHIELDS 2100

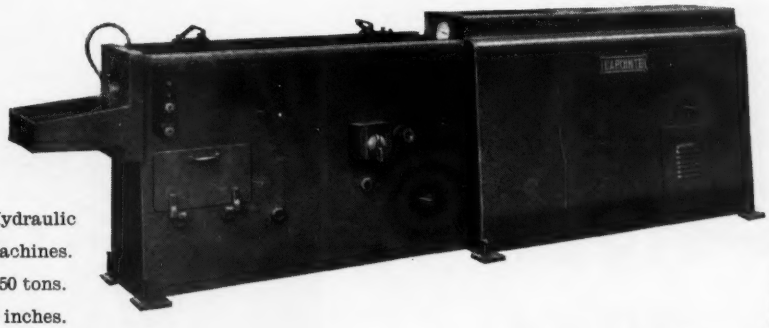
CRC 33

come to

LAPOINTE **for better broaching**



Universal Broach Sharpeners.
Capacity between centres
60, 72, 80 inches, also
Surface Broach Sharpener.
Working table 36 inches.



Horizontal Hydraulic
Broaching Machines.
Capacity: 2½-50 tons.
Stroke: 30-78 inches.

British Made

The Lapointe Machine Tool Co Ltd

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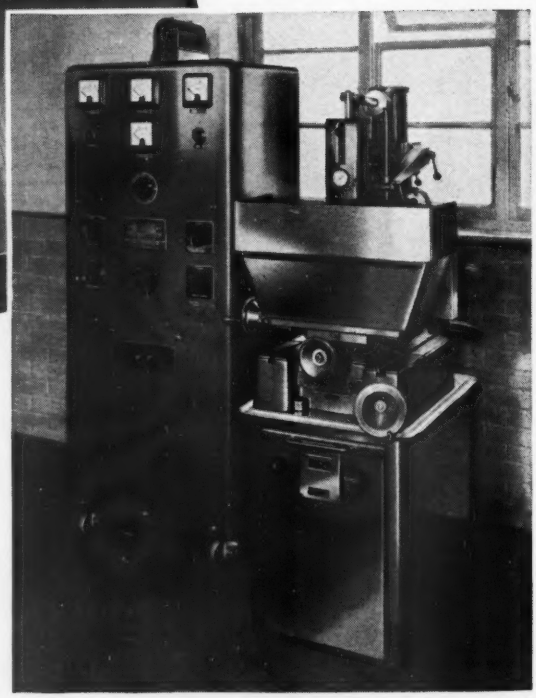
SPARK MACHINED from the SOLID

SPANNER DIE



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power elevation (as illustrated) optional

THIS IS YOUR DRILL

AJAX AJ35

Drills	1¼" dia. in m.s.
Taps	¾" dia. whit.
Radius of spindle	max. 36" or 48", min. 11"
Working area of table	30" × 22" or 36" × 24"
Working area of tilting table ...	24" × 20"
Working area of baseplate ...	35" × 26" or 47" × 26"
No. of speeds	9
Speed range r.p.m.	100 - 1500
No. of feeds	3
Motor h.p.	2
Baseplate floor area	62½" × 26½" or 74½" × 26½"
Clearance circle for arm ...	8' 0" dia. or 10' 0" dia.

table type radial

AJAX MACHINE TOOL COMPANY LTD.

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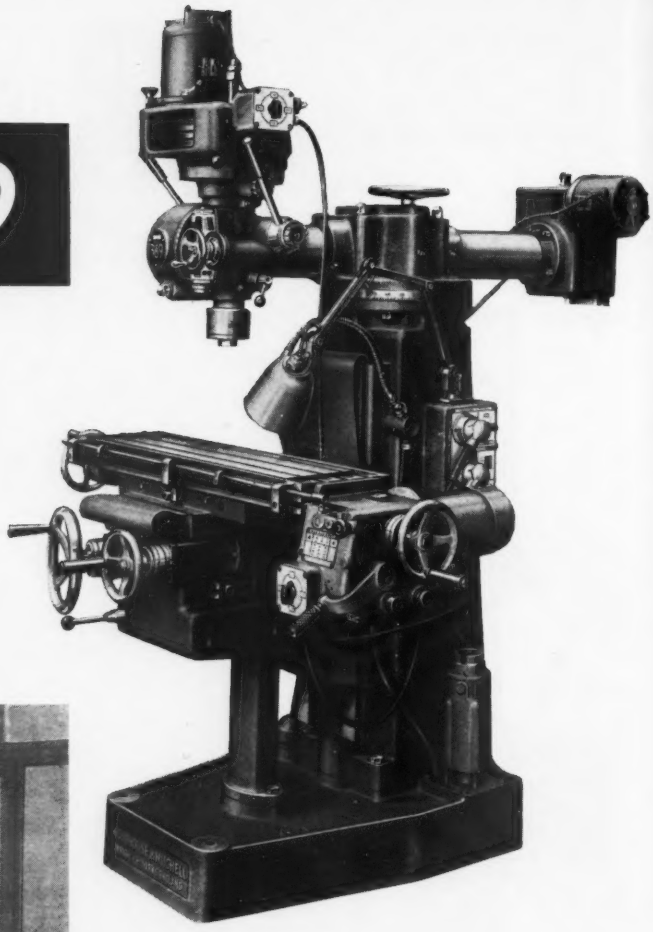
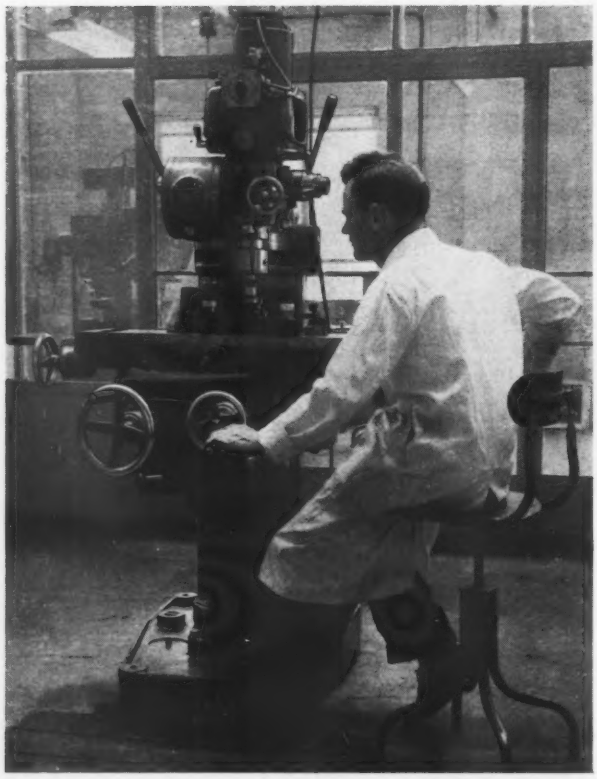
wm 369

The Versatile Turret Miller





For milling, boring, and jig boring at any angle, keyway and end milling, die sinking, mould and pattern making. The machine illustrated above is fitted with table power feed and slotting head as extras.

Illustrated left : the WM 369 at work at the P & N Tool Co. Ltd., Uxbridge.

Write for illustrated brochure : 'The WM 369.'

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WAKEFIELD ROAD
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PHONE :— BRIGHOUSE 627 (3 LINES)
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WM.28

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NEW Two-Stage Double-acting Stationary Air Compressor of Advanced Design

Type L2000

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★ HIGH EFFICIENCY
★ ALL-ROUND ECONOMY
★ COMPLETE RELIABILITY

The result of long research and development, the L 2000 has been subjected to exhaustive tests which have proved most satisfactory.

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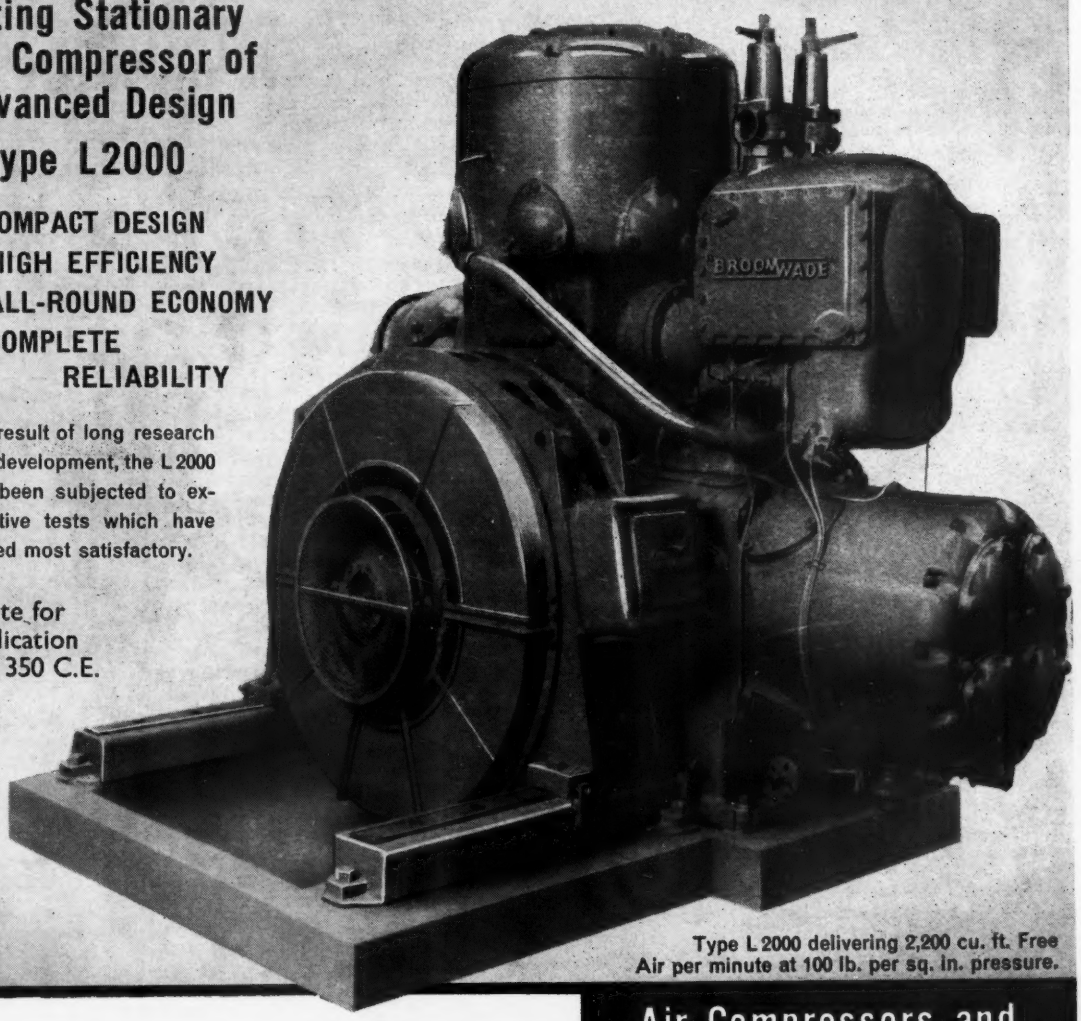

Type L 2000 delivering 2,200 cu. ft. Free Air per minute at 100 lb. per sq. in. pressure.

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Air Compressors and Pneumatic Tools
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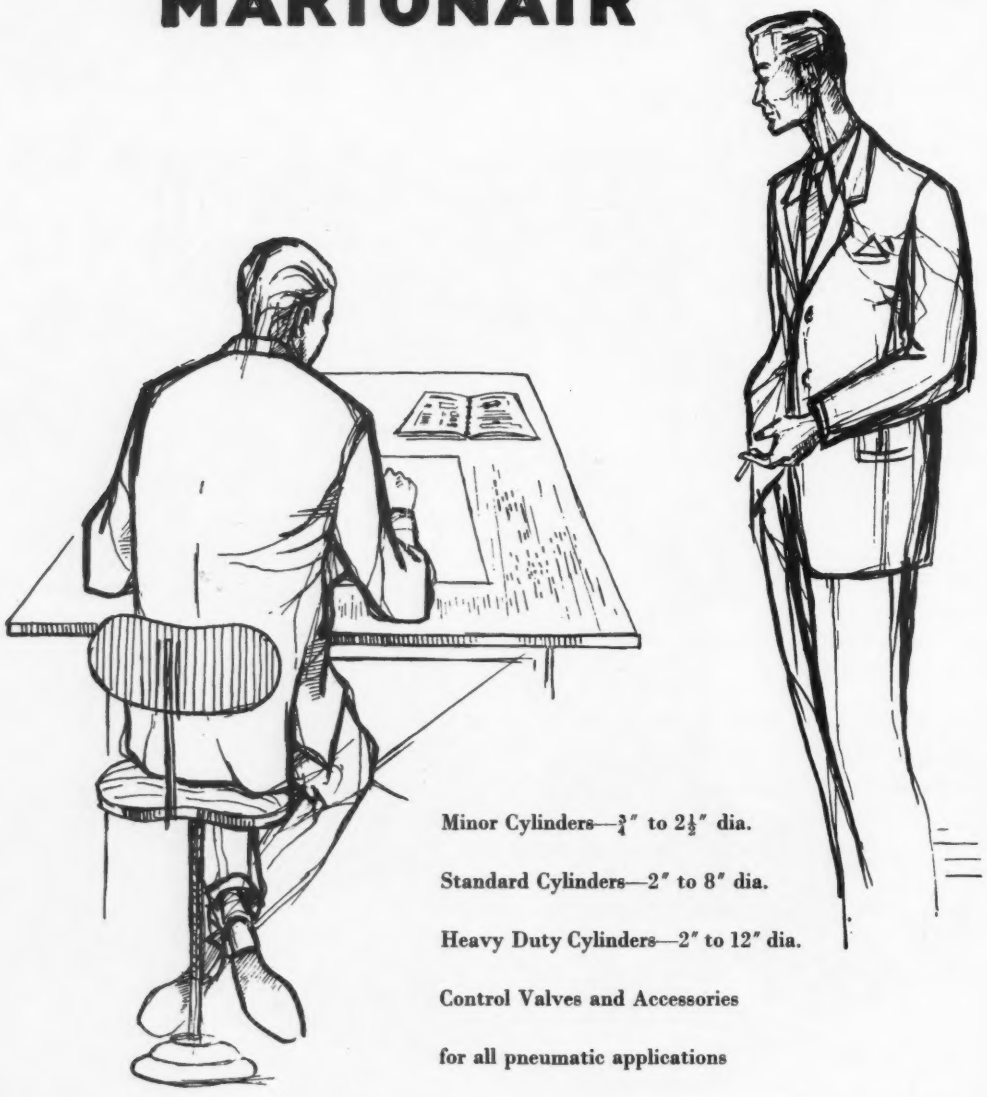
MARTONAIR



Minor Cylinders—$\frac{3}{4}$″ to 2$\frac{1}{2}$″ dia.

Standard Cylinders—2″ to 8″ dia.

Heavy Duty Cylinders—2″ to 12″ dia.

Control Valves and Accessories

for all pneumatic applications

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Also in Australia, Belgium, Canada, Denmark, Finland, Germany, Holland, Iceland, New Zealand. Norway, South Africa, Spain, Sweden, U.S.A.

A D.42

Electrical Aids in Industry *Data Sheet* **No. 4**

Resistance Heating-1

In this form of heating, the heat is produced by passing an electric current through a high resistance conductor which is termed the " heating element ".

The heat is transferred from the heating element to the work by convection, radiation or conduction, or by a combination of any, or all of these. When it is a question of radiation or convection, the element can be a bare wire or strip of suitable material, provided it is adequately supported on electrical insulation capable of withstanding the temperature.

When there is to be contact between the work and the element, heat being transferred to the work by conduction, the wire or strip must be surrounded by suitable insulating material and enclosed in a protective sheath.

In the majority of cases, the wire or strip forming the heating element is made of a nickel-chromium alloy which has a high electrical resistance and can be safely used in air at temperatures of up to 1050°C., or in a suitable atmosphere, of up to 1150°C. Other element materials are available for use at higher temperatures.

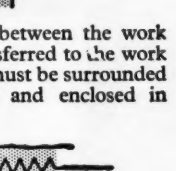
Sheathed elements, essential for contact heating but also used widely for convection and radiation heating because of the convenience afforded by the mechanical strength of the sheath, usually metallic, and by their "built-in" electrical insulation, cannot be used at temperatures as high as the bare wire or strip. This is because the wire, being embedded in insulation, is always at a higher temperature than the sheath, and to keep the wire temperature down to a safe figure the sheath temperature is usually limited to a maximum of around 800°C.

Automatic temperature control of resistance heating elements within narrow limits is easily effected, but if manual control only is desired, devices are available which enable the heat output of the elements to be controlled precisely at a required level. As with all electrical methods, a time switch may be included in the control circuit for automatically switching on or off at predetermined times, and this can enable, for example, an electric oven to be fully up to working temperature by the time the working day starts. Since there are no combustion products from the heaters, there is no need to build flues or special ventilating arrangements which also carry away useful heat.

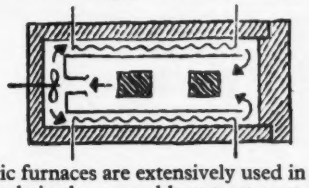
Electric resistance heating may profitably be put to many diverse uses; two of these are described briefly below, others will be listed in a subsequent data sheet.

Furnace Heating

Electric resistance furnaces can be divided into two main categories, batch type and continuous. In most cases, the heating elements are of nickel-chromium alloy, for furnace temperatures up to around 1050°C., but higher temperatures, up to nearly 3000°C., can be obtained by using other metals or alloys, or in some cases non-metallic elements. A protective atmosphere is desirable to prolong the life of some of these higher-temperature elements. For all temperatures, electric resistance furnaces can be constructed so that the heating process takes place in a controlled atmosphere if this is dictated by the composition or heat requirements of the work charge. In some furnaces, fans are used to circulate the air or special atmosphere over the charge, thereby giving increased heating rates and a uniform temperature over the whole charge.



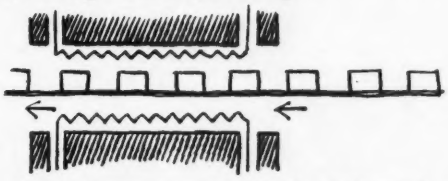
Automatic temperature control and program control of the heating process are readily effected.



Electric furnaces are extensively used in industry, for example in the general heat treatment of metals, in the glass and ceramics industries, for brazing and sintering, and for many other applications requiring temperatures above 500°C.

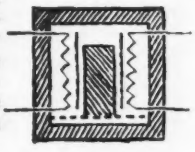
Oven Heating

There are two basic forms of heat transfer used in electric resistance ovens: convection and radiation. The latter is dealt with in a separate data sheet under the heading " Infra-Red Heating ".



Convection ovens may again be of the batch or continuous type. In either case, the charge is heated mainly by the movement of hot air, which is sometimes assisted, as in furnaces, by fans to give a rapid and uniform temperature rise. Ovens are normally designed for temperatures of up to about 500°C., and the heating elements are invariably of nickel-chromium or nickel-chromium-iron alloy.

Ventilation, when required, can be provided and regulated entirely to suit the heating process. Temperatures and times are readily controlled. A vacuum can be maintained in suitably designed ovens to assist in the extraction of moisture and solvent.



Convection ovens are extensively used for drying, baking and stoving operations, and for a host of other processes requiring a low or medium temperature.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, W.C.2.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Induction and Dielectric Heating" is an example; "Resistance Heating" is another.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue.

6780C

CUT HERE

SHELL SILICONE LUBRICANTS

150° CENTIGRADE

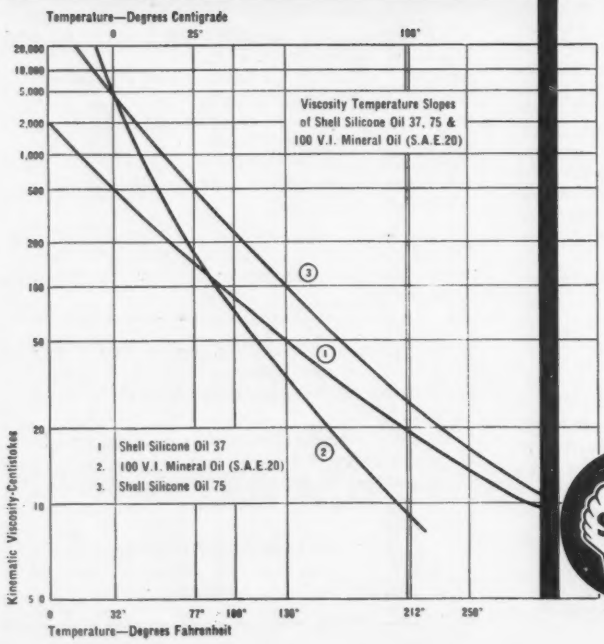
ALTHOUGH PETROLEUM OILS can operate satisfactorily in enclosed, airfree systems at temperatures in excess of 150°C, they cannot be expected to remain in reasonable condition for very long at such temperatures when in contact with air. In answer to the demand for lubricants to operate in these conditions, Shell have introduced a range of Silicone Lubricants.

SHELL SILICONE OILS are exceptionally resistant to oxidation, possess good anti-corrosion qualities, and do not thicken, gel or form gummy materials even after prolonged heating at 250 C. At even higher temperatures they can be used for short periods. Shell Silicone Oils show a relatively small change in viscosity with temperature. Further advantages are their low volatility at elevated temperatures and low pour point.

Shell Silicone Oils therefore offer distinct advantages under normal load conditions in applications where wide variations in temperature occur. Shell Silicone Oils 37 and 75 cover most viscosity requirements, and a graphited version, Shell Silicone Oil 75G, is also available.

SHELL SILICONE GREASE is a lithium base grease made with Silicone Oil. It is particularly suitable for applications where comparatively long life at temperatures around 150°C to 200°C is required, and is designed for use in low- and medium-speed, plain and rolling bearings.

Shell Silicone Grease is also available containing MoS_2 for the lubrication of sliding surfaces and antifriction bearings at temperatures above 200°C.



If you or your organisation would like to know more about Shell Silicone Lubricants, please get in touch with your local supplier of Shell Industrial Lubricants.

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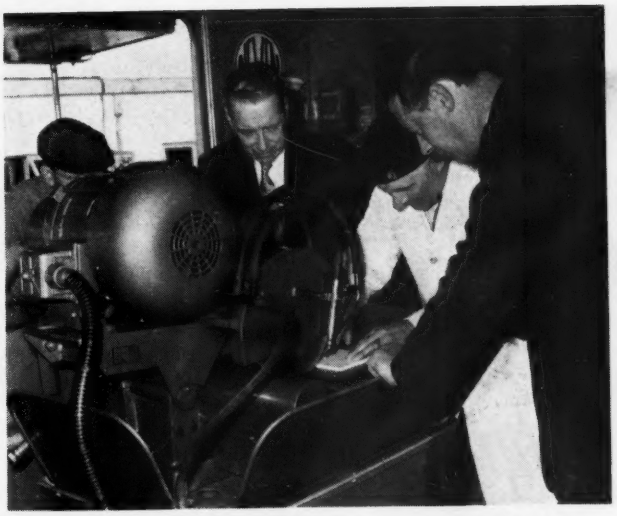

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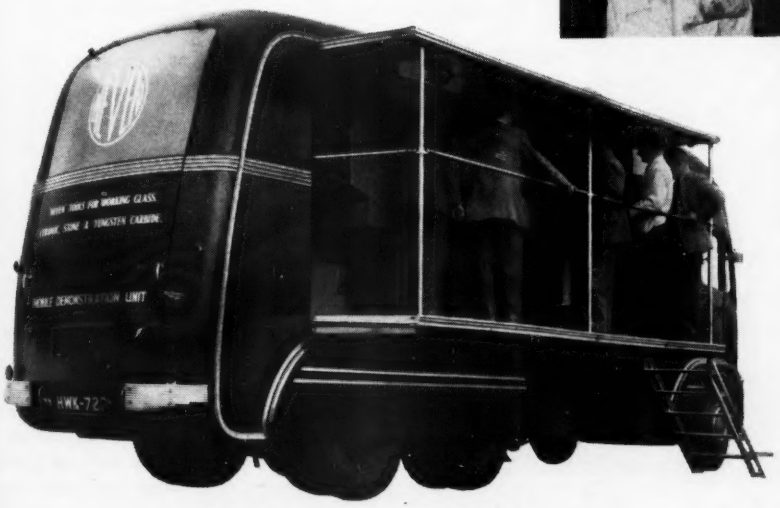

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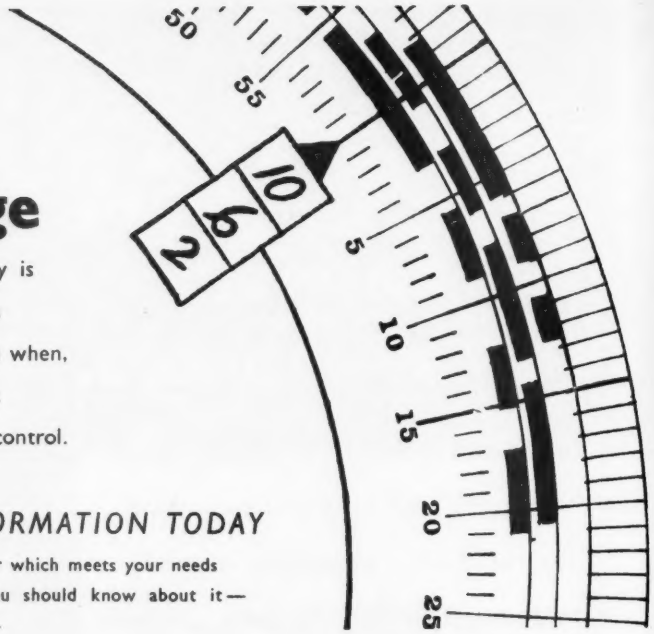

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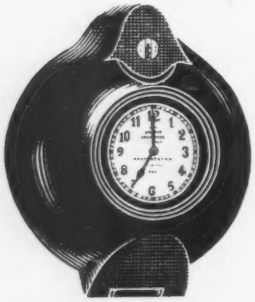
The sure measure of production efficiency is — how many minutes in the hour your machines are working. The Servis chart will tell you when, and for how long, working and idle periods occur.

This is valuable data for those who are in control.



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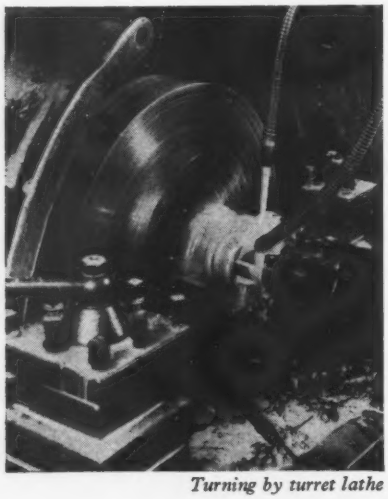

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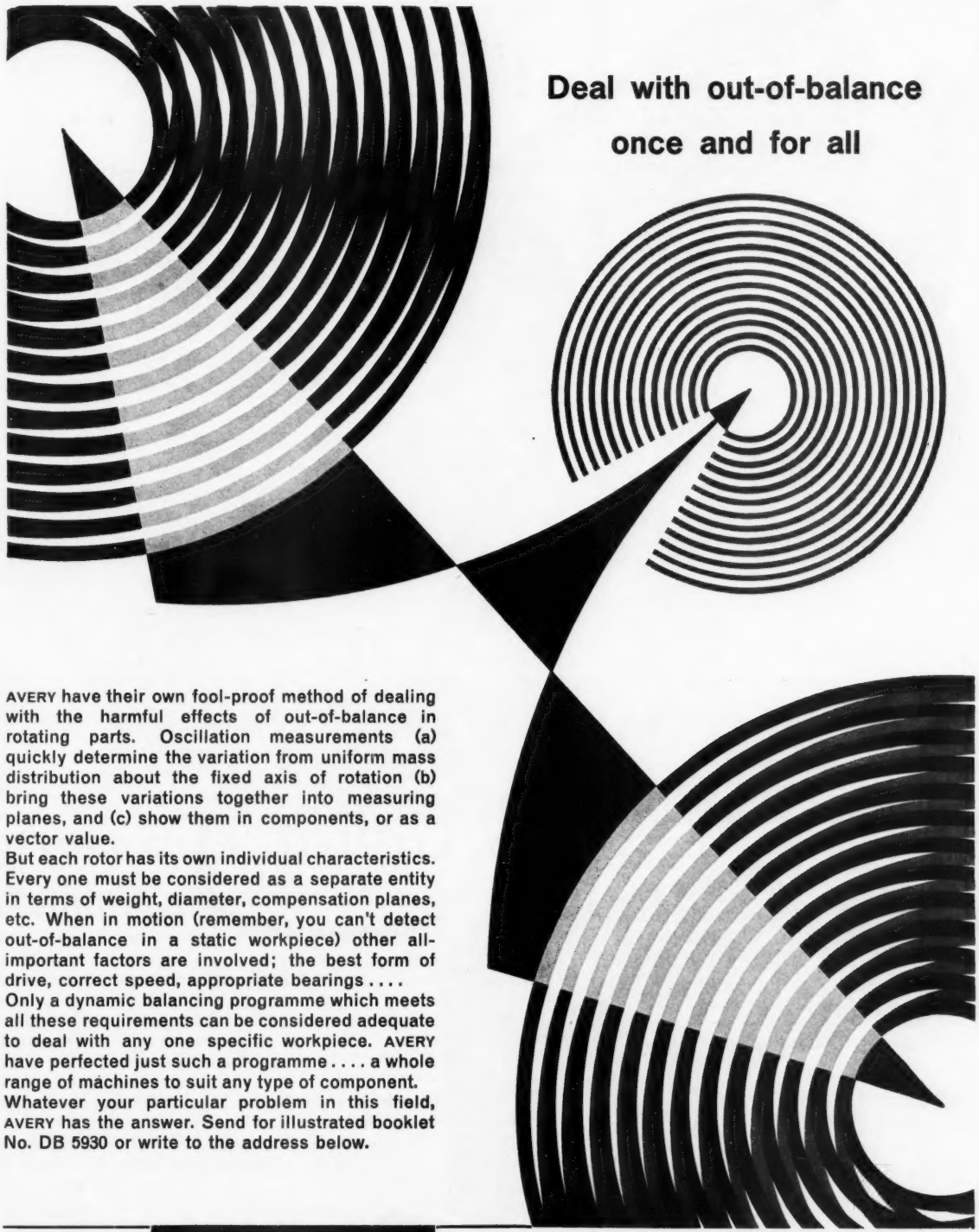

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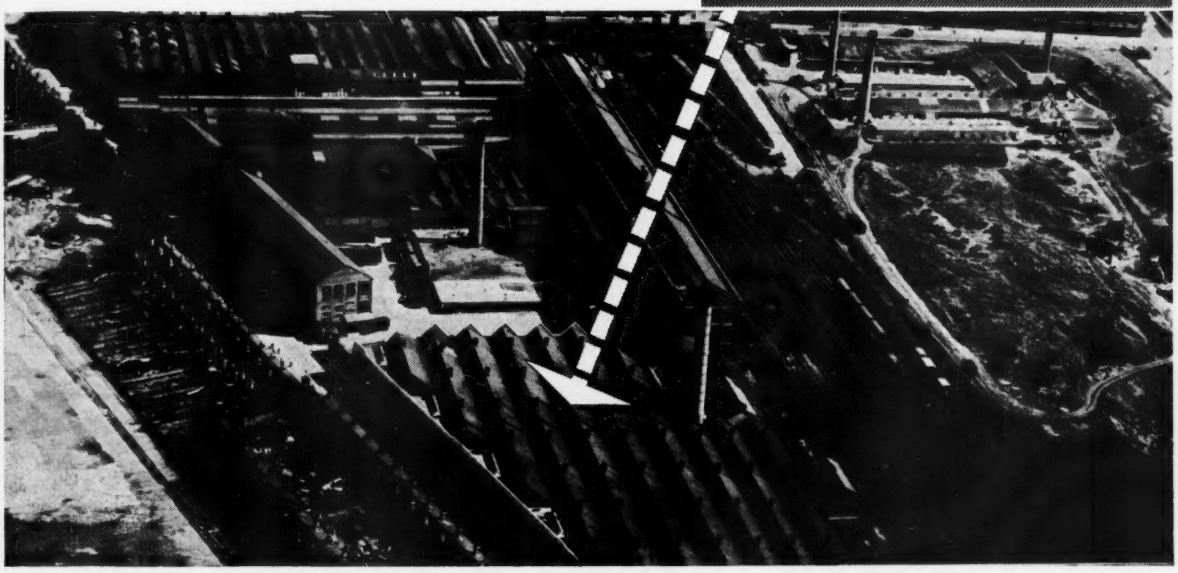

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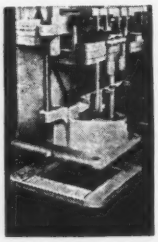

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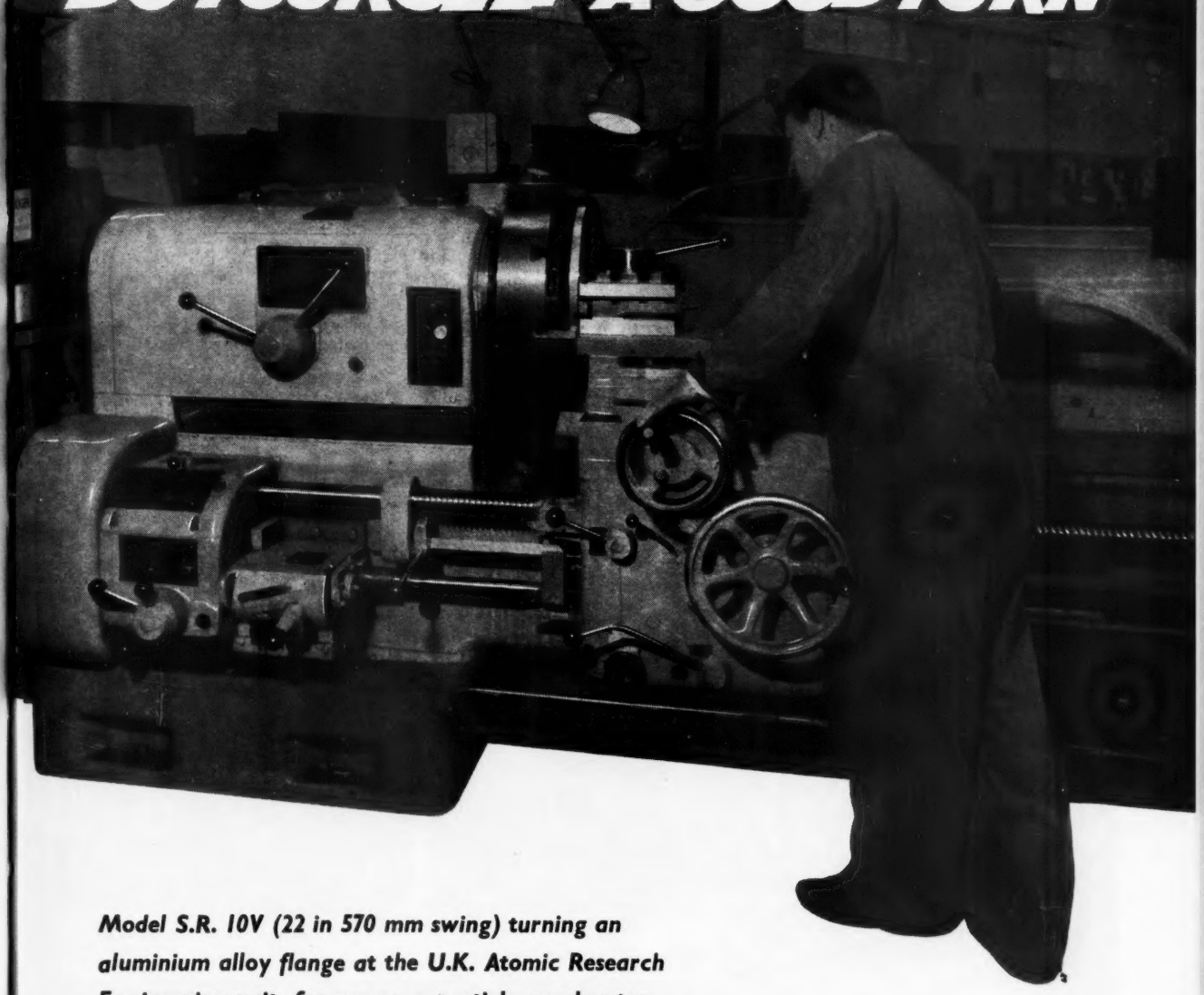

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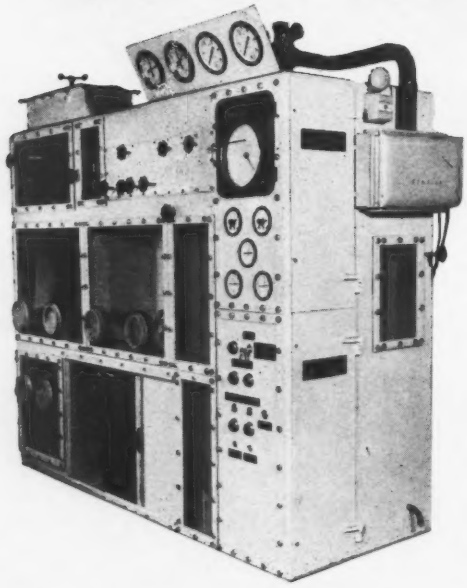

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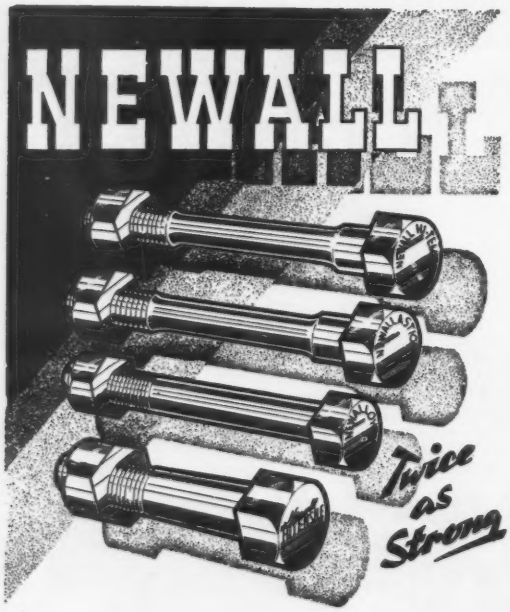

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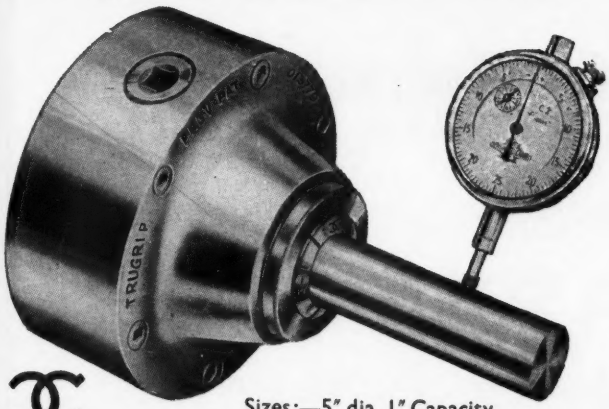

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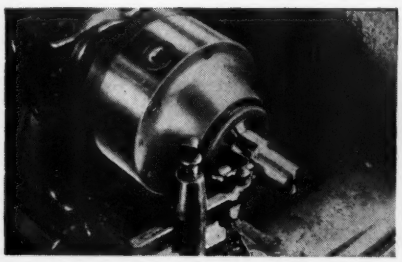
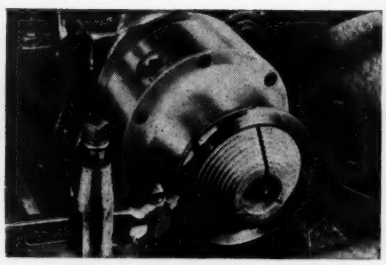
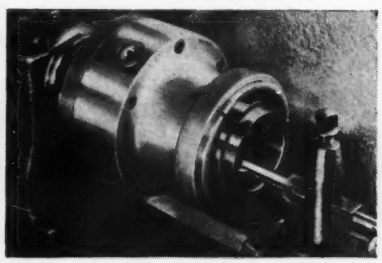
With the Crawford "Trugrip" Collet Chuck, work is held true, instantly, by the turn of a key. Absence of drawtube or sleeve means that full bore of spindle can be used. Powerful, positive action, with no distortion, and no marking of previously machined surfaces, makes it ideal for second operation work. Wide range of collets greatly increases capacity of machine, nine typical examples shown below.



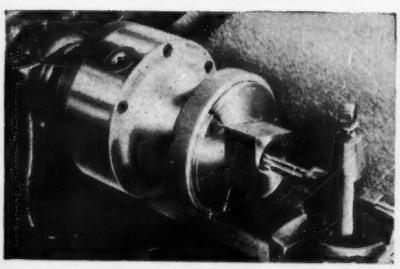
Turning using Standard Collet.



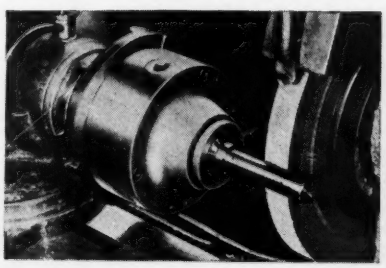
Facing and turning using Ring Collet.



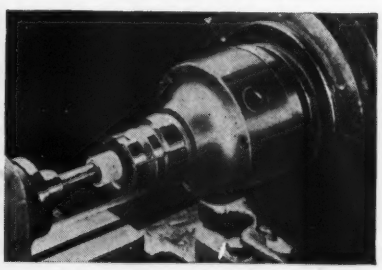
Facing and boring using Disc Collet.



Boring an irregular shaped Component. Note: Disc and Ring Collets can be supplied as soft blanks for Customer to machine to his own requirements.

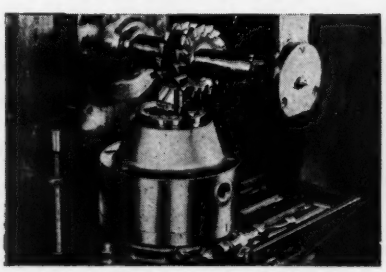


Grinding using Standard Collet.

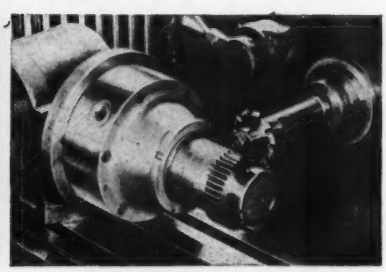


Internal grinding using Oversize Head Collet.

Grinding O.D. and face dead true with bore using expanded mandrel.



Milling using Standard Collet on Index Fixture.



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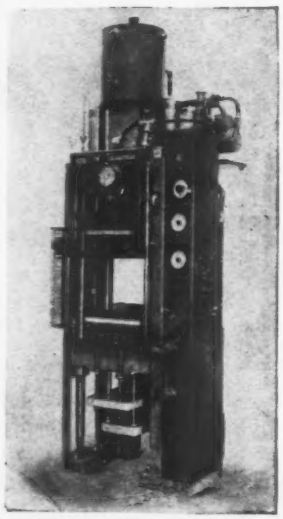

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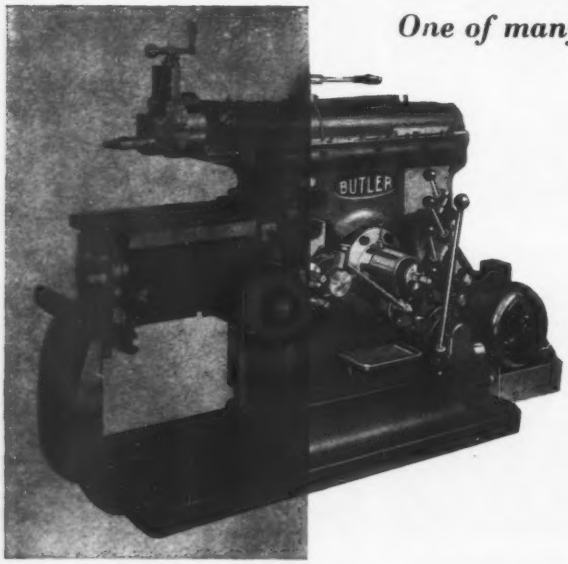

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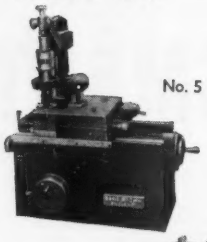

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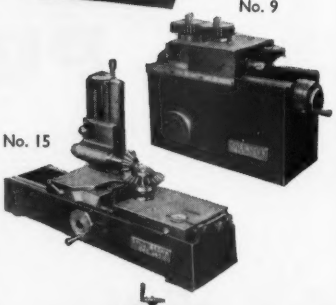

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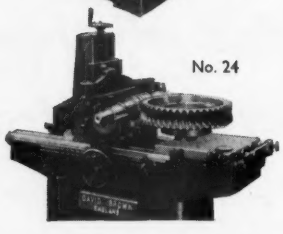

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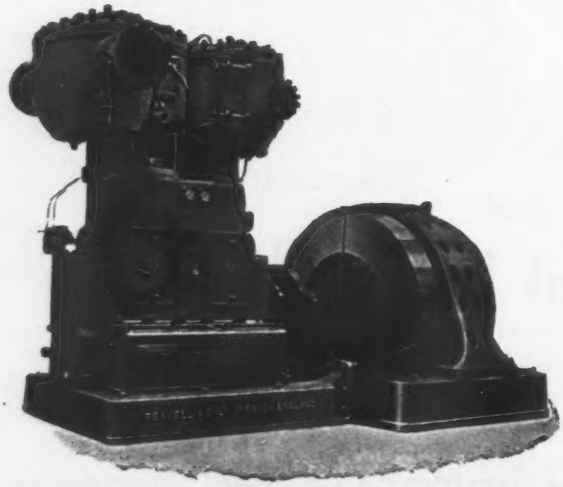

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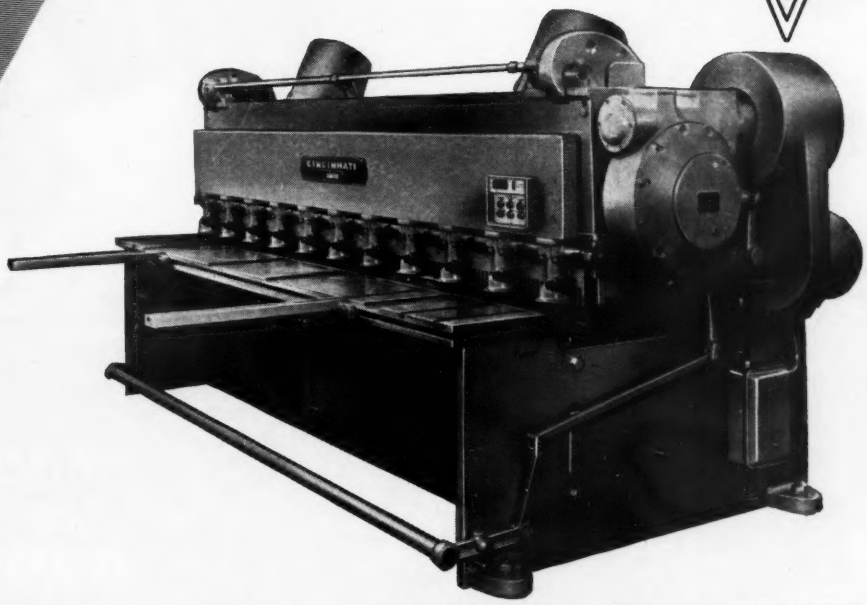

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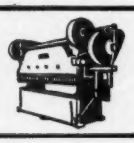

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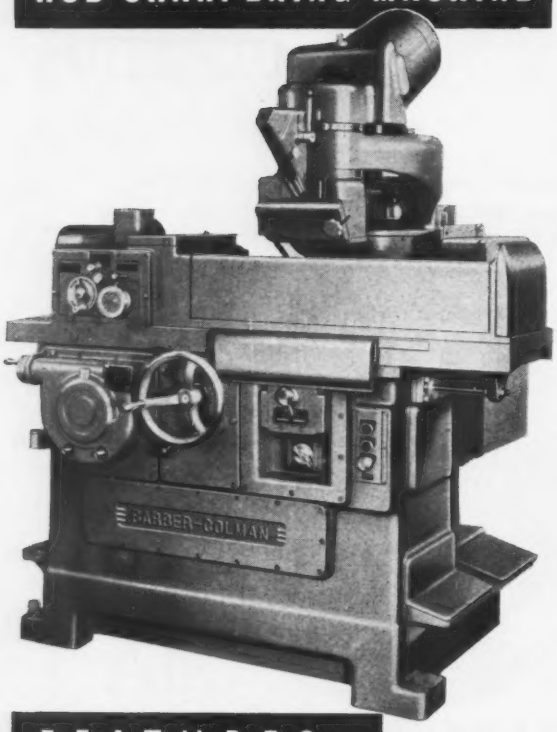
THE NEW
BARBER & COLMAN
6-5 Hydraulic
HOB SHARPENING MACHINE



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★ AUTOMATIC FEED AND INDEX COUNTING
★ UNIT CONSTRUCTION

The new Barber-Colman No. 6-5 Hydraulic Sharpening Machine is a precision machine which controls index spacing, rake angle, lead of gash, and surface finish of the cutting tool to a degree which has never before been reached by any commercial sharpening equipment. Illustrated literature available on request.

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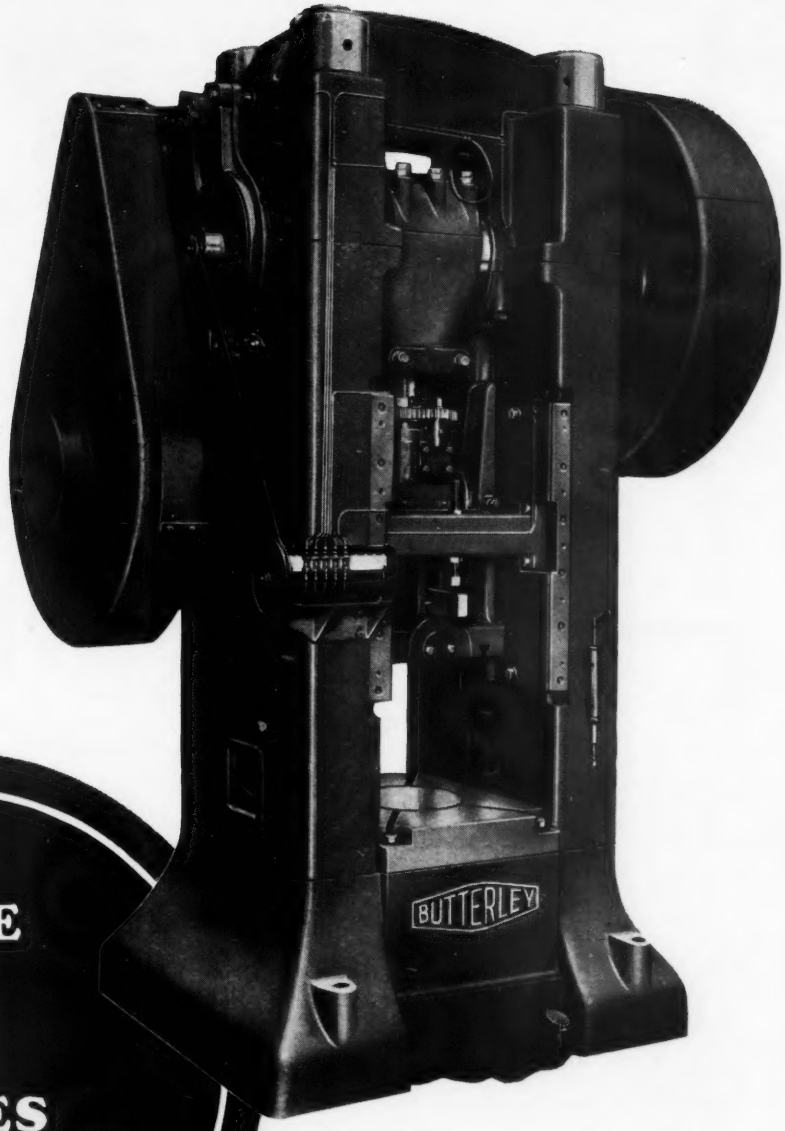

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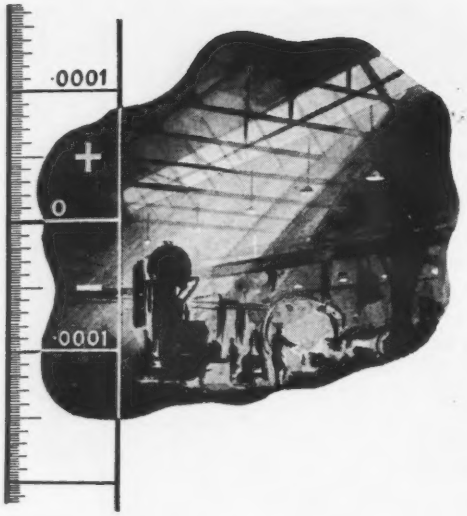

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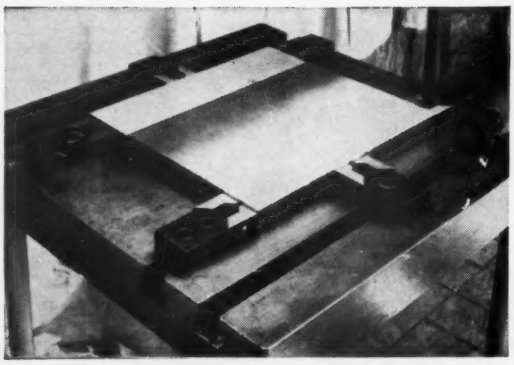
COMPOUND CLAMPING TOOL—

has proved invaluable to hundreds of firms who use it. It has a unique feature to exert simultaneously **horizontal and vertical pressure,** thus ensuring the work-piece to be safely held in position, allowing maximum stock removal at high speed. This is achieved by a double cam action in conjunction with an angular slot.



Can be used on all machine tools and also on jigs and fixtures.

Further outstanding advantages are:

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The new COMPOUND CLAMPING TOOL is made in 3 sizes and can be supplied with one or two Tee Nuts (where highest gripping power is required).
Set of Alle Keys supplied free

Size	Order Nos. With one Tee Nut	Price	Order Nos. With two Tee Nuts	Price	Length in.	Width in.	Height in.	Screw Dia. of Tee Nut in.	Approx. Weight lb.
1	59/1	1 19 0	59/2	2 8 0	$3\frac{1}{8}$	$1\frac{1}{2}$	$\frac{7}{16}$	$\frac{7}{16}$	1
2	60/1	2 12 0	60/2	3 3 0	$3\frac{7}{8}$	2	$\frac{5}{8}$	$\frac{5}{8}$	2
3	61/1	3 15 0	61/2	4 10 0	$5\frac{1}{2}$	$2\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$3\frac{1}{2}$

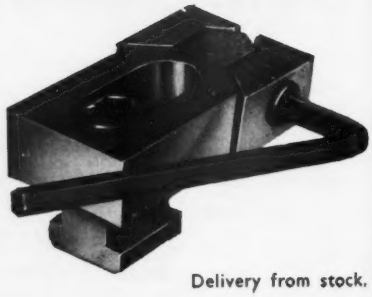

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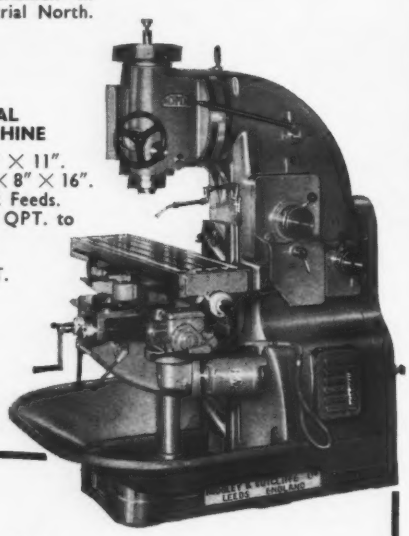
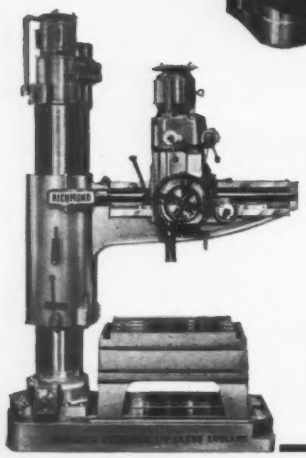
Table Size : 48" × 11".
Capacity : 30" × 8" × 16".
12 Speeds — 12 Feeds.
Automatic and QPT. to all motions.
Spindle Bored No. 40 B.S.S.T.
Head Swivels 45° Right or Left
3" Vertical Spindle adjustment.





H.B. 3/12 RADIAL DRILLING MACHINE

12 Spindle Speeds 20 - 960 R.P.M. or 40 - 1800 R.P.M.
4 feeds — .004 to .013 ins./rev.
Pillar dia. 12".
Spindle bored No. 4 Morse taper.
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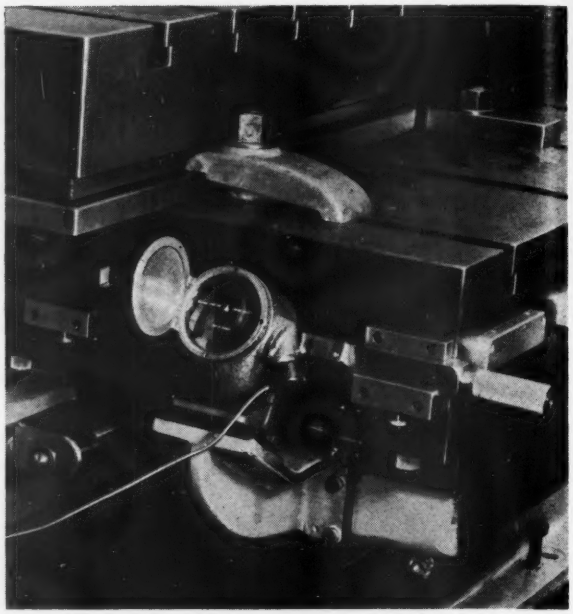

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With the Microptic Scale Reader, machine tools, measuring instruments, etc., can be set and controlled accurately, simply, and without fatigue or eye-strain.

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Accuracy : Maximum error, 0.0006 in. in any 12 in., 0.001 in. in any 48 in. Errors are random and not cumulative.

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The scale reader is small and easy to fit to the majority of machine tools, etc. It has many refinements, all described in our catalogue CT 141/b25.

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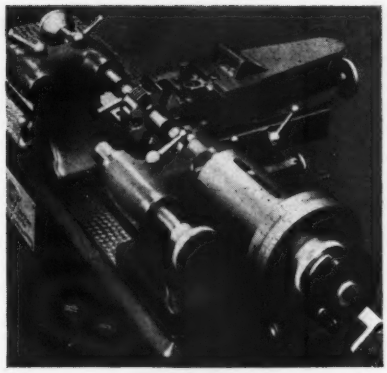
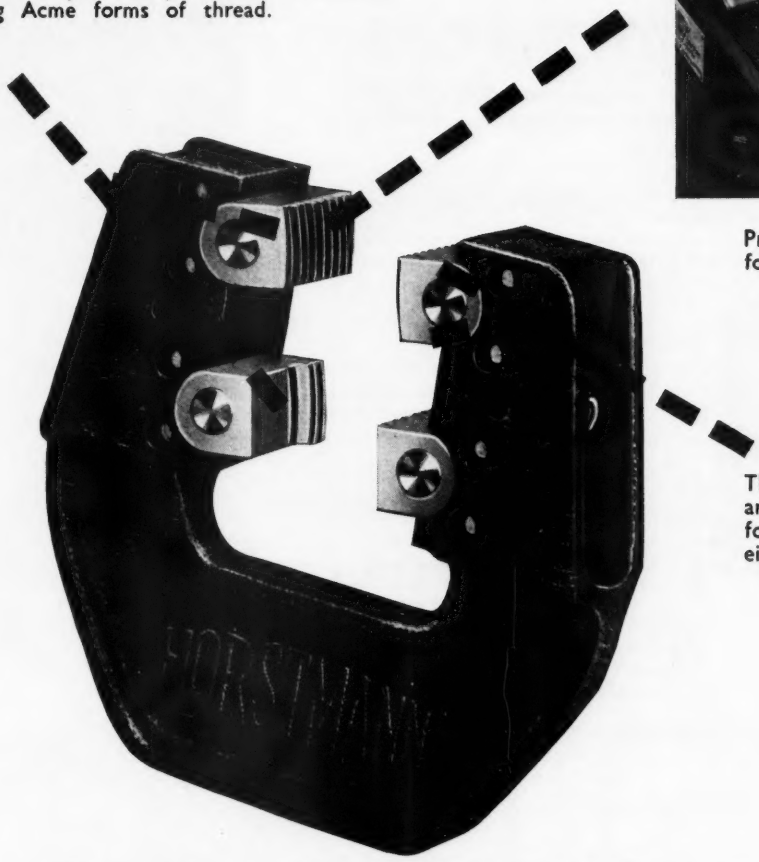
CT/141/b25

Because of the depth of anvil section the caliper is particularly suitable for gauging Acme forms of thread.



Precision measuring machine for checking the pitch of the anvils.



The radiused anvils do not roll and having annular-thread forms, they can be used for either left or right hand threaded work pieces.

Featuring Horstmann gauges

The Horstmann Model 52 Screw Caliper Gauge puts accuracy in your hands. In addition to the features displayed above it incorporates many other advantages all of which contribute to fine accuracy, versatility, long life and ease of handling. All shearing action is eliminated — adjusting screws allow for a wide range of work diameters and tolerances and obviate the necessity for regrinding — the absence of projections makes the caliper suitable for gauging shouldered work and Model 52 is available in a full range of B.A., American, Unified, Whitworth and Metric forms of thread. It is normally supplied as a 'GO' and 'NOT GO' combination gauge so that both tests can be applied in one action, but is also available as 'GO' only or 'NOT GO' only.

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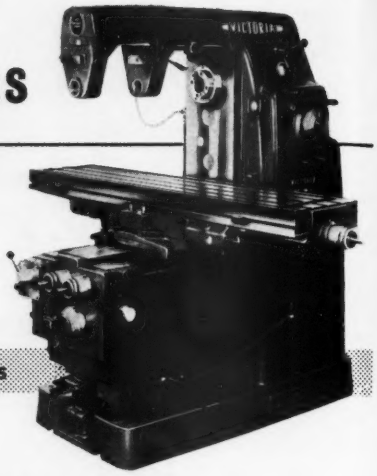
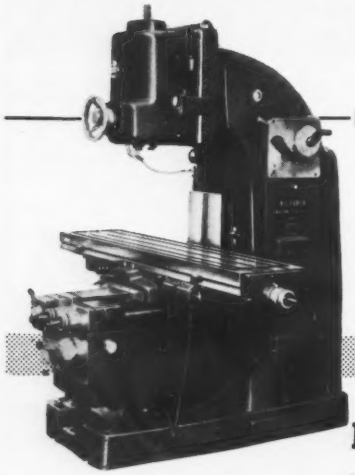
VICTORIA U4 AND V4 MILLING MACHINES



MODEL U.4

Power and rapid traverses to all table movements.
12 spindle speeds, 22 - 1,020 r.p.m.
54 longitudinal feeds, 0.5 - 30.5 in./min.
7½ h.p. spindle motor, independent 3 h.p. feed motor.
Spindle, feed and rapid traverse control by patent single lever 'Monotrol' unit.

£2800 including 3 phase electrics



MODEL V.4

Power and rapid traverses to all table movements.
18 spindle speeds, 20 - 1,000 r.p.m.
54 longitudinal feeds, 0.5 - 30.5 in./min.
10 h.p. spindle motor, independent 3 h.p. feed motor.
Spindle, feed and rapid traverse control by patent single lever 'Monotrol' unit.

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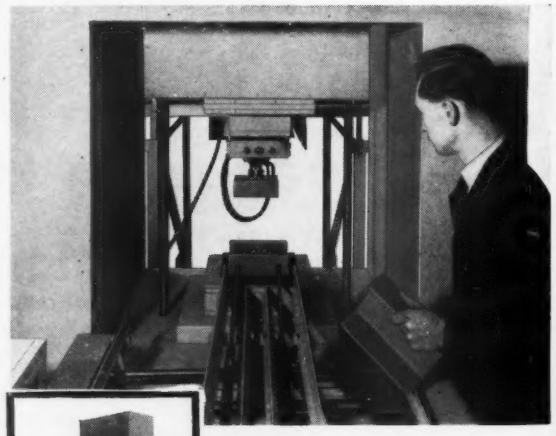

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Time Saving
The Loader permits continuous feeding with the minimum of Operator movement. The two units together on a Press running at 15 s.p.m. will give a production rate of 800 per hour with one Operator. With manual loading, two Operators would do well to reach 360 per hour.

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Easy changeover from one job to another. Mounted on castor wheels with built-in height adjustment, the Units can be rolled clear for toolsetting or moved to another machine and reset within minutes.

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Relative to the savings in production costs from the use of these Units, their prices including installation, are attractive.

Labour Saving
The Unloader either replaces an Operator at back of Press or enables the front Operator to concentrate solely on feeding.

UDAL

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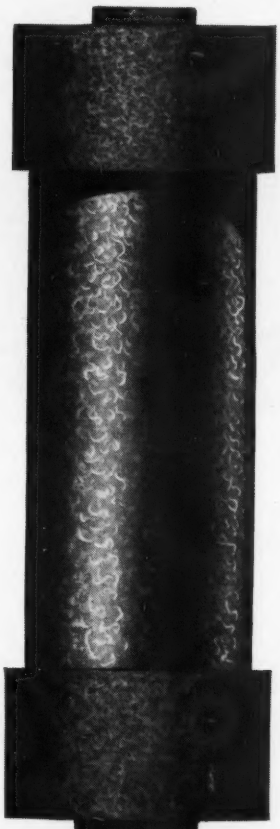

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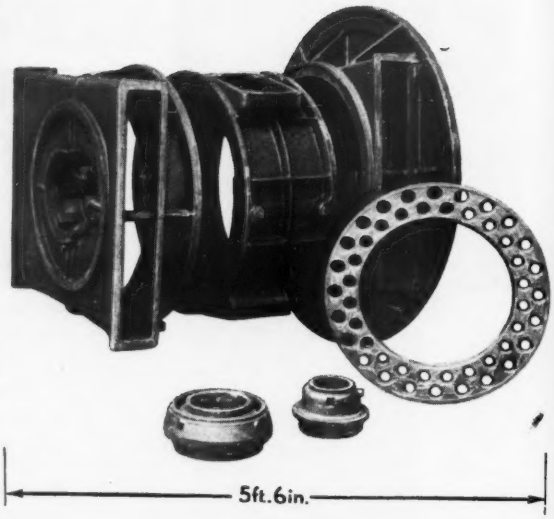

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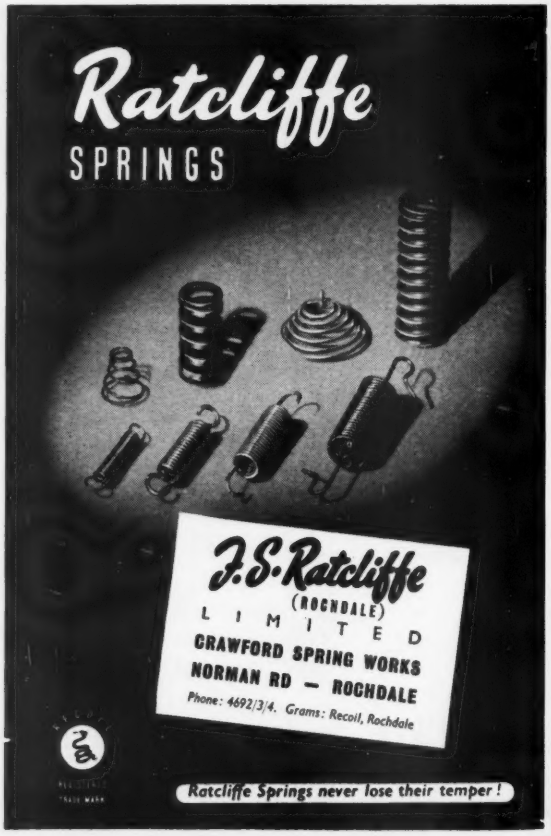

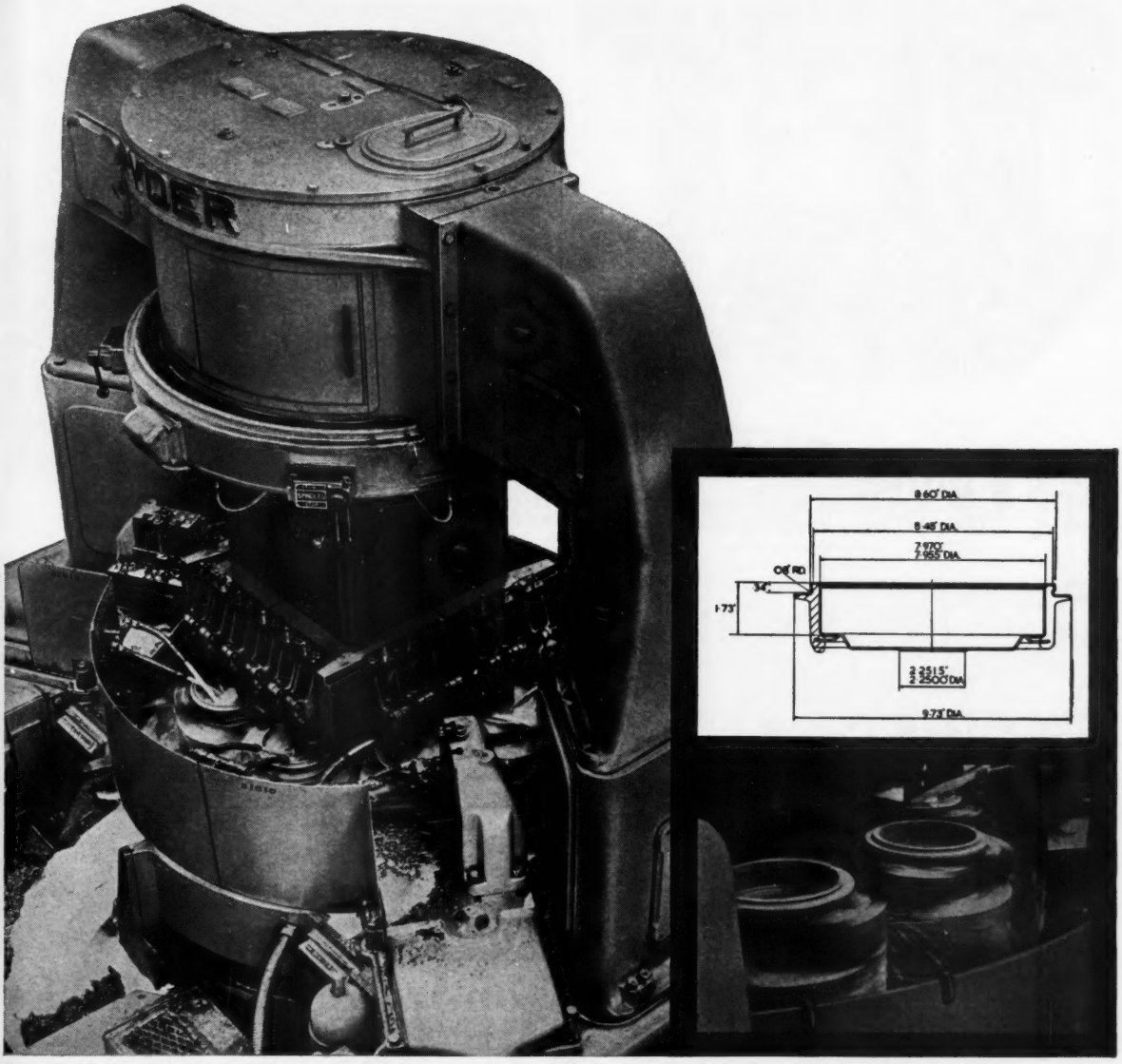

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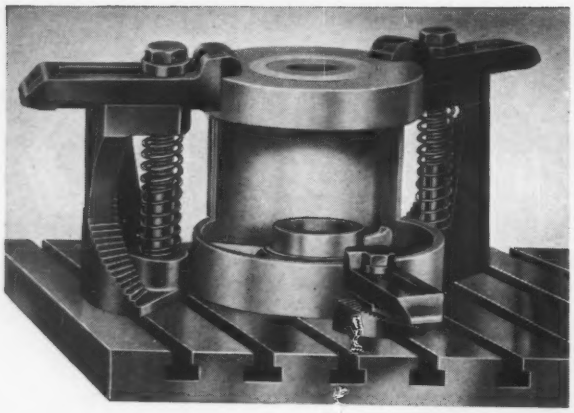

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Any quantity Ex stock.

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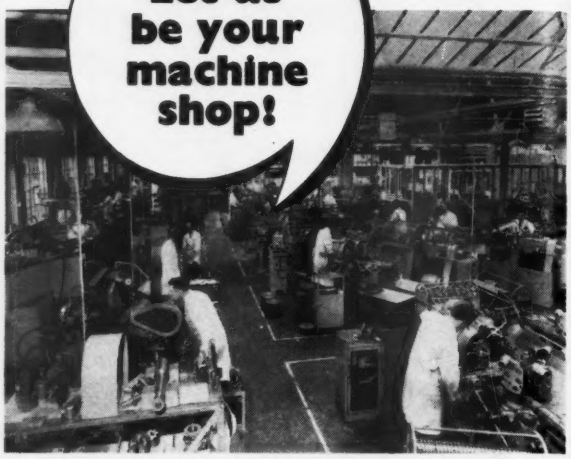

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CUTS OVER-ALL MACHINING TIME BY 80%

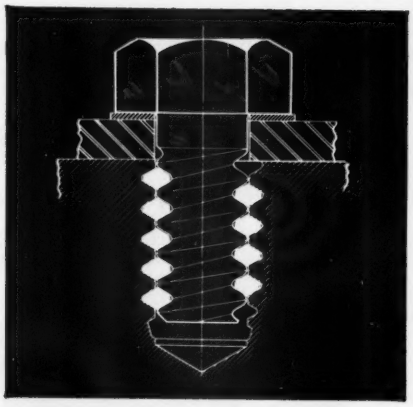
on *Sterling* slip flasks

Wadkin Articulated Arm Router L.C. face milling the end plates of the Sterling slip flask shown right. Photographs are reproduced by courtesy of Sterling Foundry Specialties Ltd., Bedford.

Here is yet another example of how the latest Wadkin High Speed Routers completely outdate all previous methods of machining light alloys. Since installing a Wadkin Articulated Arm Router L.C., Sterling Foundry Specialties Ltd., have drastically reduced production times on their aluminium slip flasks. All the face milling operations, including the milling of inside faces to an angle of 4°, are accurately machined in a fraction of the time previously taken, and no further finishing operation is required. Why not let us prove the amazing output capabilities of this machine — preferably by a demonstration on your own jobs. Meanwhile, write for a copy of leaflet No. 831 which describes the machine and its applications.

Wadkin

Wadkin Ltd., Green Lane Works, Leicester. Tel.: 68151 (7 lines) London Office : 62-64 Brook Street, W.1. Tel.: MAYfair 7048



almost limitless possibilities of saving in time and cost

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screw thread inserts

Heli-Coil Inserts are self-anchoring thread liners made from high tensile stainless steel wire. In tapped holes they provide a conventional thread with higher loading strengths and greater resistance to wear and stresses than unprotected threads. The Heli-Coil eliminates stripping, seizing, galling and corrosion. It literally *armours* the thread. The Heli-Coil offers a unique opportunity for product cost revision. It is "a natural" for automation, it can make dramatic cuts in time and labour costs. Assembly is the ultimate in simplicity — just drill, tap and install. The Heli-Coil saves weight and space. It improves the serviceability and appearance of the end product. We suggest you write soon for data on Heli-Coil, the British-made Insert that is available internationally. It is a product of the day and this atomic age.

For further details write for Sales Leaflet APL 48/E8.

ARMSTRONG PATENTS CO. LTD. EASTGATE, BEVERLEY, YORKSHIRE

BEVERLEY 82212

* *HELI-COIL is a registered trade mark*

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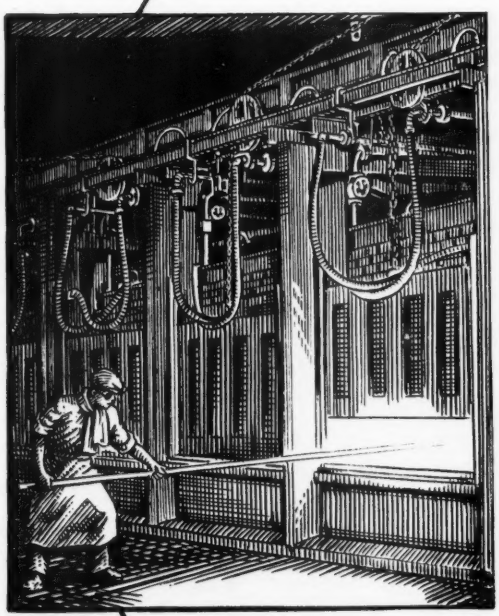

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Rounds from $\frac{3}{8}$″ to $9\frac{1}{2}$″.
Hexagons from $\frac{3}{8}$″ to $3\frac{5}{8}$″.
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Hexagons $\frac{37}{64}$″ to 1″ in 900 lb. coils.
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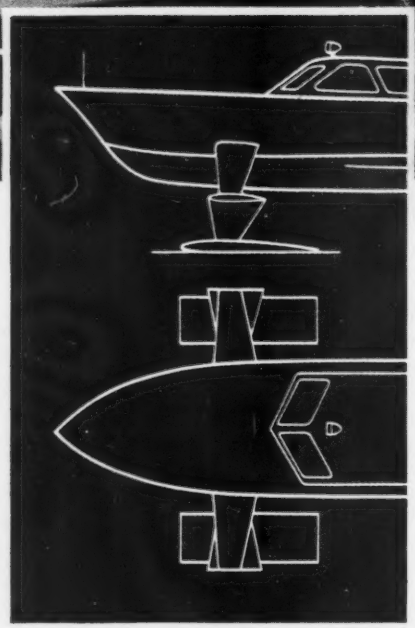

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Today gas is *the* fuel in forging, annealing, rivet heating and other basic heat processes in shipbuilding and heavy engineering; gas also has specialised applications such as drying before shot blasting. Industrial Gas research and consumer service ensure that tomorrow gas will be Britain's most economic fuel . . . **AND TODAY—** every industry and 12 million homes use **GAS.**

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